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EDITORIAL

CITRONELLA

THE article on the present position of the trade in Ceylon citronella oil by Dr. A. W. R. Joachim which appeared in the last number of this Journal merits something more than passing notice from our readers. The production of this commodity for export is one of the most important minor agricultural industries of the Island, and its importance is enhanced by the concentration in one small area in the Southern Province of the whole industry which brought Rs. 686,000 to the producers in a very lean year like 1935.

The progressive fall in prices has alarmed the growers of the citronella grass and, during the last three years, they have maintained a persistent agitation for the establishment of a citronella experimental station by the Government to investigate the possibility of turning out a superior quality of oil which would command a higher price in the world market. The expression "superior quality" in this connection is used to connote a higher geraniol content in the oil. The methods suggested from time to time for raising the quality of the oil brought to the market are the enforcement of severe legislative measures against adulteration and the introduction and acclimatization of the variety of grass, locally known as Mahapengiri, which has been found to yield an oil with a high percentage of geraniol in Java.

While admitting that some degree of adulteration does take place, Dr. Joachim raises the question whether anything would be gained by preventing this. It would appear that the trade divides citronella oil into two definite classes—oil with a high geraniol content and oil of fair average quality, commonly known as f.a.q. The uses to which the two grades are put are so distinct that they may be regarded as two unrelated commodities. F.a.q. is determined by a prescribed test. Oils that do not pass this test are rejected ; oils that do pass it are not graded in different classes. Attempts have been made from time to time to introduce to the market an estate product of guaranteed purity which contains a higher percentage of geraniol than the f.a.q., but not so much as the superior grade. The reply of the exporters was : " This is excellent oil ; but this excellence is not demanded by the consumer, and therefore we cannot pay more for it than for f.a.q." Therefore what the dissatisfied citronella planter seeks is not an improvement in the quality of the oil they now produce, but the production of an oil which will enable them to compete with the Java grower in the market in the higher grade.

It is taken for granted that these superior oils cannot be produced from the variety of grass, commonly known as Lena-batu, which is grown in this country. It remains to decide whether a determined effort should be made to introduce Mahapengiri or the Java variety. Dr. Joachim does not advise that such a step be taken. The Mahapengiri requires a richer soil than is commonly found in Ceylon and more intensive methods of cultivation than the Lena-batu now receives or the growers can be expected to practise. It has a shorter age than Lena-batu and lends itself to less frequent harvesting. These disadvantages more than counterbalance the small difference in the present prices. Even that difference will not be maintained if the Ceylon grower abandons the production of f.a.q. and enters into competition with the Java exporters.

These considerations point to the conclusion that the future of the citronella oil industry lies in the better cultivation of the Lena-batu, and in greater care exercised in the extraction of the oil. It is for Government to decide whether it should establish a research station to investigate these minor cultural and manufacturing improvements which should not be beyond the capacity of individual citronella planters.

CEYLON ESTATE COPRA

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RECORDED oil percentages of copra from various producing countries are very variable, and standard textbooks quote a range of from 57 to 75 per cent. The sources of these figures vary in reliability and in many cases are far from representative. Cooke (1) has pointed out that copra badly deteriorated through mould attack may give an abnormally high yield of (inferior) oil. This is ascribed to the fact that moulds first attack the inside of the pieces where the oil content is lowest. Many of the high figures in the earlier literature may refer to such low grade copra. Lewkowitsch (2), for example, mentions the high acid values of copra oils examined by him in the early 1900's.

Unusually low figures for oil, on the other hand, often refer to analyses of small samples, and in such cases the nuts from which the copra was derived may have been immature. This is obviously the case with analyses of samples from Queensland reported in 1916 (3).

Nevertheless definite variations do occur, apart from such causes as the foregoing, and, whilst no definite conclusions can be drawn from the data available on any possible influence on oil content of such factors as climate (in its widest sense), soil type, manurial treatment, and genetic differences, it is possible to detect some regularities. Thus Cooke (4) gives the following table of oil content of copra and nut size for various countries, which appears to relate the oil percentage inversely to size of nut, the smallest dwarf nuts giving the highest percentage oil yield. A recent analysis of copra from dwarf Maldive nuts by Child (5) gives some support to this view.

TABLE I.

(From Cooke, "The Coconut Industry of the Philippine Islands," 1936, p. 93).

OIL CONTENT OF COPRA AND NUT SIZE FOR VARIOUS COUNTRIES

Country	*Approximate Oil Content*	*Number of nuts per Ton of Copra*
Trinidad Cocos Islands	70	.. High—possibly 10,000
Malabar Zanzibar West Indies	69	.. Various—Average 6,250
Ceylon West Africa	68	.. About 4,800
South Seas Java	67	
Philippines Straits Netherlands Indies	66	.. About 4,500 ,, 4,500

For Malayan Estate Copra there is fortunately on record a fairly comprehensive set of analyses by Georgi (6). It seemed desirable to carry out a similar comparative set of determinations on Ceylon Estate Copra. Seven estates in different parts of the Island have kindly co-operated to make this possible—their situations are as follows: two in the Western Province (Mirigama and Kalutara districts respectively), three in the North-Western Province (Puttalam, Chilaw and Kurunegala districts respectively) and one each in the Eastern and Southern Provinces. As is well known, the common practice in Ceylon is to pluck every two months, and the co-operating estates have accordingly sent samples from every curing during the year from November, 1935 to October, 1936, except for one Superintendent who varies the usual practice by plucking monthly and who accordingly has sent twelve monthly samples.

Under "Miscellaneous" are included four samples as follows: two random samples from estates not included in the original seven, and two samples taken from bulk in Colombo stores.

SAMPLING AND ANALYSIS

It was desired to make the present determinations strictly comparable with those of Georgi (*loc. cit.*) and his methods were accordingly followed as far as possible.

Samples of about fifty halves drawn from bulk were received here and the examination commenced immediately on receipt.* Georgi's method of reduction of the sample for analysis, *viz.*, cutting transverse slices from each individual piece was followed and was found to give concordant results on duplicates, which were also in good agreement with those given by a method previously used in which small pieces are punched out with a cork-borer.

Drying.—The observation on the browning of the thin copra slices when dried at 100°C. was confirmed. The loss of weight on so drying, as Georgi remarks, may not accurately represent the true moisture content, but can be regarded as a measure of it, and the present figures are comparable among themselves and with Georgi's.

Extraction.—The extraction method employed differed only from Georgi's in the use of a Bolton-Revis extractor instead of a Soxhlet apparatus. This somewhat expedites extraction. Both methods are a sufficiently close approximation to that recommended by Allen and Auerbach (7). Light Petroleum (B. Pt. 40-60°C.) is the most satisfactory solvent for oil extraction, although some duplicate extractions with "Analar" Ether indicated that the use of the latter solvent introduced no serious error in the case of copra analysis.

Iodine values, (by Wijs' method), saponification values and percentage free fatty acid (as lauric) were determined on all the extracted oil samples. All determinations were carried out in duplicate.

RESULTS

The results are summarised in the following tables. Table II shows for each estate the maximum, minimum and average values for moisture content, oil content (both wet and dry basis)

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* It should be noted that the samples were in transit for different lengths of time depending on the distance of the producing estate from the Coconut Research Scheme laboratories and the convenience or otherwise for rail transport. Thus consistently higher moisture percentages are recorded for the Estate (No. 3) situated nearest. Too much should not be made, therefore, of the differences in the average moisture content between copra from one estate and that from another

TABLE II

ANALYSES OF CEYLON ESTATE COPRA

1935-1936

No. of Estate	Province	No. of Samples	% Moisture			% Oil			% Oil (Dry Weight)			Oil. Average values for:		
			Max.	Min.	Average	Max.	Min.	Average	Max.	Min.	Average	Iodine Value	Saponification Value	F.f.a. (lauric %)
1	W.P. ..	6	7·4	5·1	6·5	65·5	62·8	64·1	69·2	67·8	68·5	8·2	258·6	0·07
2.	E.P. ..	6	7·4	5·8	6·8	64·8	63·2	63·9	69·5	67·9	68·6	8·0	256·8	0·07
3.	N.W.P.	6	8·9	7·4	8·2	63·8	61·3	62·3	69·0	66·5	67·8	8·2	256·9	0·06
4.	W.P. ..	12	8·1	5·6	7·1	65·0	61·7	63·0	69·1	66·5	67·8	8·2	259·4	0·06
5.	N.W.P.	6	6·8	6·0	6·4	65·0	63·1	64·3	69·3	67·5	68·6	8·0	259·8	0·05
6.	S.P. ..	6	7·9	5·6	6·4	65·4	63·4	64·4	69·7	68·1	68·8	8·3	261·1	0·05
7.	N.W.P.	6	7·2	5·2	6·1	65·3	62·9	64·3	69·0	67·6	68·5	8·2	260·4	0·05
Miscellaneous		4	7·9	4·5	6·3	65·3	62·0	63·9	69·2	66·7	68·2	8·0	258·9	0·15
Total ..		52	8·9	4·5	6·8	65·5	61·3	63·7	69·7	66·5	68·3	8·16	259·1	0·06

and the average figures for the Iodine values, saponification values and free fatty acid percentages of the extracted oils. Tables IIIa and IIIb show respectively all the moisture and oil (dry basis) determinations arranged in groups having successive ranges of one per cent. with the Malayan figures (Georgi, *loc. cit.*) for comparison. Table IV shows the average values for moisture content, oil content (dry basis) and Iodine value, arranged in groups according to the time of plucking the nuts. Table IVb is the same omitting the estates in the Eastern and Southern Provinces.

TABLE III

(*a*) Moisture %			(*b*) Oil % (dry basis)		
Group	*No. of Determinations*		*Group*	*No. of Determinations*	
	Ceylon	Malaya		Ceylon	Malaya
4- 5%	1	7	62-63%	0	1
5- 6%	11	6	63-64%	0	5
6- 7%	21	19	64-65%	0	14
7- 8%	14	19	65-66%	0	14
8- 9%	5	10	66-67%	4	25
9-10%	0	1	67-68%	14	3
			68-69%	24	0
			69-70%	10	0
Total	52	62	Total	52	62

TABLE IV

(*a*) ALL ESTATES

Dates of Plucking	*No. of Samples*	*Average Moisture %*	*Average Oil % (dry basis)*	*Average Iodine Value*
1935 Sept.-Oct.	3	7·3	68·0	8·0
,, Nov.-Dec.	8	6·8	68·7	8·4
1936 Jan.-Feb.	9	6·2	68·2	8·4
,, Mar.-April	8	6·7	68·5	8·0
,, May-June	8	6·6	68·4	8·3
,, July-Aug.	8	7·2	68·0	7·8
,, Sept.-Oct.	6	7·3	68·3	7·9
Total	50	6·8	68·3	8·15

(b) ESTATES ON WEST OF CEYLON

Dates of Plucking		No. of Samples	Average Moisture %	Average oil % (dry basis)	Average Iodine Value
1935 Sept.-Oct.	..	2	7·4	67·6	8·1
,, Nov.-Dec.	..	6	6·6	68·6	8·5
1936 Jan.-Feb.	..	7	6·2	68·2	8·4
,, Mar.-April	..	6	6·8	68·3	8·05
,, May-June	..	6	6·7	68·4	8·3
,, July-Aug.	..	6	7·5	67·9	7·8
,, Sept.-Oct.	..	5	7·6	68·0	7·9
Total	..	38	6·9	68·2	8·14

It may be said at once that no definite variation in the percentage oil content of the copra with the situation of the estate can be established from these results. Even the maximum difference observed, that between estates Nos. 3 and 6, does not appear to be statistically significant. For the 52 samples the following statistical constants were obtained :—

Mean percentage of oil	..	68·30
Standard deviation ..	..	0·764
Standard error of the mean	..	0·106
Coefficient of variation	..	1·119

These figures indicate that the value 68·30 is a reasonably accurate one for the average dry weight oil percentage of Ceylon Estate copra. The group table IIIb confirms this, 38 out of 52 samples (*i.e.*, 73%) falling in the two groups 67-68 and 68-69%.

The lack of definite variation in the oil percentages is all the more surprising since there has been an impression that copra from the Batticaloa District (Eastern Province) has a definitely lower oil content than that from the western side of the Island ; further, the Eastern Province nuts are known to be larger on the average and, if oil content is inversely correlated with nut size, might be expected to show a lower oil percentage.

Neither is it possible from the figures recorded here to establish any relation of oil content to the time of year at which

the nuts are plucked—see table IVa and b—even when, as in table IVb, consideration is given only to estates situated on the western side of the Island, which are subject to more or less the same weather cycle. The moisture content naturally shows a tendency to be higher in the wetter seasons.

It was less unexpected to find little variation in the composition of the extracted oils as indicated by their Iodine and saponification values, since coconut oil is one of the least variable of the commercial fats. For example, Allen and Moore (8), working in 1925 in the Research Laboratories of Messrs J. Crossfield and Sons, Ltd., Warrington, studied the oils of nuts from a wide variety of sources—42 samples from 12 widely different countries—and concluded that " coconut oils from such widely separated districts as the East and West Indies possess chemical characteristics which are essentially identical." Thus, of their 42 recorded Iodine values, 35 fall between 7 and 9, between which range all of the present recorded 52 samples lie.

In a previous publication (9) an average Iodine value of 8·75 was quoted for Ceylon coconut oil. This is too high owing to the inclusion of samples from inferior copra. Figures from commercial samples of oil have since averaged 8·23.

THE PRACTICAL OIL YIELD OF CEYLON COPRA

For comparative purposes oil percentages are calculated on the dry weight, *i.e.*, as percentages of the moisture-free copra. The actual oil percentage in the copra as received will obviously depend upon its moisture content ; for an average sample of copra of oil percentage 68·30 (dry basis), a rise of one per cent. of moisture will mean a decrease in oil percentage of 0·683. Thus a sample containing the average amount of moisture as recorded for Ceylon Estate copra, namely 6·8 per cent. and the average amount of oil, contains actual oil percentage 63·7 approximately.

Commercially obtainable yields of oil from Ceylon copra using an efficient expeller are stated to be between 62 and 63 per cent.*. Before expression, copra is usually subjected to a heat treatment

*It is of interest that in calculating world oil statistics of production, etc., the factor 63% is used in converting copra to coconut oil, for example in Fehr & Co.'s "Review of the Oilseed, Oil and Oil Cake Markets."

and can be regarded as then containing about 4 per cent. of moisture (see below), and an oil percentage averaging 65·6. After expelling, therefore, between 2·6 and 3·6 per cent. of oil (calculated on the 4 per cent. moisture containing copra) remains in the poonac. There would be obtained accordingly 37-38 per cent. of poonac containing about 11 per cent. of moisture and between 6 and 9·5 per cent. of oil (neglecting losses on working and loss of moisture by evaporation). Actual (unpublished) analyses of Ceylon expeller poonac have averaged 8·2 per cent. of oil and 10·4 per cent. of moisture.

If copra with much more than 4 per cent. of moisture be pressed, moisture is apt not to be retained completely in the poonac, but to pass into the oil, rendering it turbid. It is not uncommon for analytical reports to show the percentage of oil in copra on a 4 per cent. moisture basis (cf. Allan and Moore, *loc. cit.*), as copra is usually at about this moisture content when pressed.

A sample of copra meal, as disintegrated and dried ready for pressing, kindly sent by the British Ceylon Corporation, showed the following results:

Moisture	4·02%
Oil	66·6 %
Oil (dry basis)	69·4 %

THE MOISTURE PERCENTAGE OF COPRA

It will have been apparent from the foregoing that, as far as can be seen, the producer has little control over the oil content of his copra.* It is otherwise with the moisture content, the control of which is, in fact, the copra curer's foremost aim. The discussion of how to achieve this aim is outside the scope of the present article, but it will be worth while discussing the subject of the moisture content to which copra should be dried in connection with the actually observed moisture percentages of typical Ceylon Estate copra. These are best surveyed from table IIIa.

It is well known that the keeping qualities of copra depend upon its moisture content. Walker (1906) (10) recommended that copra should be dried to 5 per cent. moisture content and

*It is shown later (page 147) that the rate of drying influences somewhat the oil percentage (dry basis) and indeed accounts for some of the difference between Ceylon and Malayan copra in this respect. The percentage of oil is altered in this way by a change in the weight of the other (dry) constituents, the absolute amount of oil remaining unaltered. The phrase "oil content" in the text can therefore stand.

long storage avoided. Brill, Parker and Yates (1917) (11) give a figure of 6 per cent. Lava (1928) (12) reported that the "critical moulding moisture content" under a relative humidity of 81 per cent. and at room temperature was 8 per cent. and stated that such copra may be kept for at least a month without moulding or acquiring a rancid odour. Passmore (13) records observations on copra stored in a London riverside warehouse from March to October, 1930 under an average relative humidity of 84·6 per cent. The copra remained mould-free during this period and he concludes that copra once dried to 6-7 per cent. moisture content does not re-absorb sufficient moisture under ordinary conditions to support even a superficial mould growth.

Between 6 and 7 per cent. may therefore be regarded as a reasonable recommendation for the moisture content of copra, and it is of interest that of the 52 samples of Ceylon Estate copra, 19 are above 7 per cent. and of these only 4 above 8 per cent.

The question of re-absorption of moisture under damp conditions has been touched on above. There will clearly be a point for every degree of relative humidity (the temperature being constant) at which the moisture of the copra and the atmosphere will be in equilibrium. Passmore (*loc. cit.*) regards this as about 5 per cent. under English conditions, *i.e.*, copra drier than this will absorb moisture from the air until its content reaches 5 per cent. and copra wetter will dry out to 5 per cent. Cooke (14) records that in Malaya the moisture content of good copra freely exposed to the air fluctuated between 3·5 and 8 per cent. In the low-country of Ceylon (unpublished) observations of a similar nature show a range of 5·2 to 7·9 and it is of interest to note that in the case of sun-dried copra, which can be regarded as having been dried to equilibrium point, an average moisture content of 7·8 per cent. has been found.

All of these observations confirm that copra dried to 6-7 per cent. if stored in a well-ventilated, dry store at an even temperature will not seriously deteriorate. It is apparent that there is little to gain by drying copra much below 6 per cent. moisture content, although in the past much more stringent recommendations have been made; for example, the Imperial Institute in 1916 quoted the advice of an oil-seed crusher to reduce the moisture content to 3 per cent. (15).

Even a moisture content of up to 8 per cent. seems unlikely to cause serious trouble if subsequent storage conditions are satisfactory, as it will dry out to some extent in transport and in store. Samples from good stores have been found to have dried at as low as 4·5 per cent. (*cf.* the sample included under "miscellaneous"), and none of the present samples on storage showed more than superficial mould growth. At the same time drying only to 8 per cent. moisture (and this is still more true in the case of samples from 8-9 per cent.) allows little margin for the possibility of exposure to bad conditions and there is evidence that more penetrating moulds (*e.g.*, *Aspergillus flavus*) can grow on such copra, that is, unless such copra dries out fairly rapidly it will deteriorate. Colombo brokers have stated, too, that sun-dried copra (which as has been mentioned contains on the average rather more moisture than the 6·8 per cent. average of No. 1 kiln-dried), though initially better in appearance, does not keep so well as good kiln-dried.

Accordingly the recommendation of 6-7 per cent. seems the most satisfactory, with the proviso that up to 8 per cent. will not matter at the time of completing curing if subsequent storage before crushing is such that some further drying out will occur. Apart from the consideration of deterioration the question of moisture content will interest the buyer (as opposed to the seller) from the point of view of the final oil yield calculated as a percentage on the weight of copra as bought.

PERCENTAGE OF FATTY ACID IN THE EXTRACTED OIL

Roughly, the free fatty acid percentage can be regarded as a measure of the rancidity of the oil, though they do not run exactly *pari passu*. The figures given in the present study are of no comparative value, but are recorded to demonstrate that the copra samples as analysed were fresh and undeteriorated.

COMPARISON OF CEYLON WITH MALAYAN COPRA

One of the primary objects of the present study was to obtain a sufficient basis for a comparison of Estate copra from Ceylon and from Malaya. The differences are set out in tables IIIa and b. There is no great disparity in moisture content. The average oil percentage (dry weight) for Malayan Estate copra found by Georgi, (*loc. cit.*) was 65·6; that of the present

series for Ceylon Estate copra is 68·3. Cooke (16) quotes analyses of 3 parcels of No. 1 Ceylon copra as follows: (*a*) 70·13, (*b*) 68·72 and (*c*) 68·2 per cent. oil (dry weight) and other similar figures are on record. Fritsch (17) quotes for a sample of Ceylon copra 68·6 per cent. The most recent and authoritative handbook on oils and fats (18) gives the following average figures:—

Straits copra	65-66·5%
Dutch East Indies ..	65·8-67·5%
Ceylon	67-69·5%

It can be regarded as established, therefore, that there is, or at least was, a fairly regular difference of from 2 to 3 per cent. oil percentage in favour of Ceylon copra. Apparently more than one factor contributes to this difference. Cooke's experiments (19) indicate that a higher oil percentage results from slower drying. This has already been referred to. It is thus possible that Malayan copra will tend to improve in this respect, although since slow drying gives a lower yield of copra which more than sets off the improved oil percentage, there is little commercial advantage either way. Even allowing for the effect of different rates of drying, it still appears that Ceylon nuts will give copra of higher oil percentages than Malayan nuts, since Cooke found a difference of about 1 per cent. between copras from Ceylon and Malayan nuts respectively, both cured under the same conditions. Much more information is necessary before any attempt can be made to account for this one per cent.

CONCLUSION

It should be made clear that this article refers to Ceylon Estate No. 1 copra only. The grades recognized in Ceylon generally and at the Colombo Sales Room in particular are Estate No. 1, No. 2 and No. 3 and mixed (F.M.S.) In view of the interest taken in sun-dried and fine white No. 1 and the fact that reasonable premiums are usually now obtained for superior samples (largely owing to their ultimate use for edible purposes in India), it is probable that a definite superior grade of copra will be recognized. Most Ceylon Estate No. 1 is satisfactory in all but appearance and by suitable modification

of kilns to prevent smoking could probably be brought up to a higher grade. This will be discussed in a later publication.

Estate copra constitutes only about 25 per cent. of the copra produced in Ceylon, the remainder being largely small-holders' copra handled by dealers. There has been a definite improvement in the quality of dealers' copra since the establishment of the Colombo Sales Room early in 1936 and much of it is little inferior to Estate copra. It is proposed to supplement the present work by carrying out a series of analyses on Estate Nos. 2 and 3 qualities and on samples of dealers' copra so that eventually there will be provided a complete survey of the quality of all types of Ceylon copra.

SUMMARY

1. Analyses have been carried out on 52 representative samples of Ceylon Estate No. 1 copra, 48 of which were received at regular intervals during the course of one year from seven estates in different parts of Ceylon.

2. The general average composition was moisture 6·8 per cent., oil 63·7 per cent., oil (dry basis) 68·3 per cent.; extracted oil—Iodine value 8·16, Saponification value 259·1, free fatty acid (lauric per cent.) below 0·1 per cent. in the case of the freshly cured estate samples.

3. These figures are compared with recorded results for 62 samples of Malayan Estate copra, which averaged moisture 6·9 per cent., oil (dry basis) 65·6 per cent. The difference of oil percentage is partly due to the slower process of drying adopted in Ceylon and partly to an unexplained fundamental difference between the nuts of the two countries.

4. Upon expelling, Ceylon Estate copra, dried to 4 per cent. moisture content, may be expected to give a practical oil yield of 62-63 per cent., and 37-38 per cent. of poonac containing about 11 per cent. of moisture and 6-9·5 per cent. of residual oil, depending upon the efficiency of the expeller.

5. It is not possible to detect any regular variation of oil content or composition with the time of plucking or with the situation of the estate of origin. The slightly lower average oil contents of copra samples from Estate Nos. 3 and 4 may be due to the fact that the palms on the estates are older than

those of the others; the evidence is indefinite as the differences are not statistically significant.

6. There seems little need in most cases to recommend more stringent drying of Ceylon Estate copra. The only direction in which improvement is aimed at is in the preparation of white copra, as the present sales method in Colombo initiated this year (1936) usually ensures a premium for quality superior to Estate No. 1.

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AGRICULTURAL IMPLEMENTS*—IV

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THE MARKER

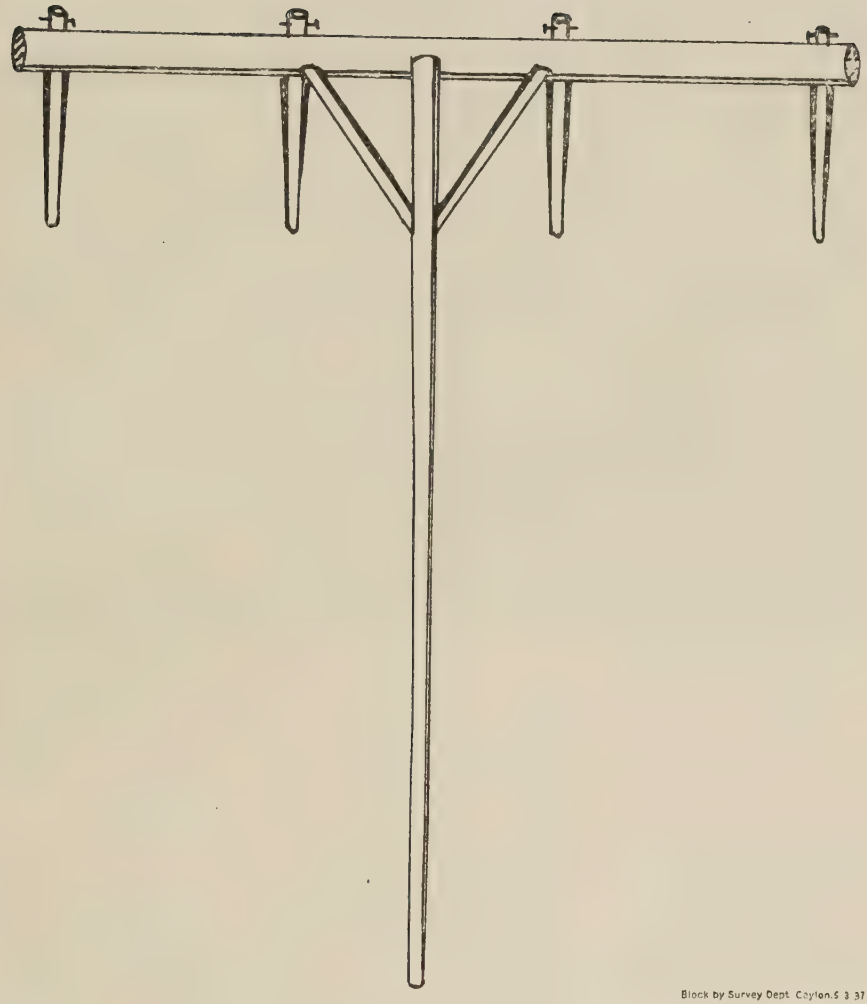
THE marker is a simple hand implement consisting of a light piece of wood forming the head-piece ; a pole about one and a half to two inches in diameter and about 6 to 7 feet in length, fixed at right angles to the head-piece serves as the handle. The joint is further strengthened by two pieces of wood, bracing the head-piece and the pole together. Two to four wooden teeth fixed vertically downwards and at right angles to the head-piece complete the implement.

As this is a hand implement, the teeth should be so fixed as to reduce the draught to the minimum. The space between the teeth and the number of teeth vary with the crop to be planted and with the nature of the soil. The same marker can be used for differently spaced crops by having a set of holes drilled in the head-piece. The teeth can be adjusted according to requirements.

After the preliminary operations of ploughing, cross ploughing and harrowing the soil and levelling and compacting the seed bed, the next step is to sow the seeds or to transplant the crop. Transplanting of crops like tobacco, chillies, tomatoes or brinjals or the dibbling of seeds like cotton and maize should always be done in straight rows. This facilitates intercultivation with implements worked by bullocks and also renders harvesting operations easy. The common system of lining out fields with coir strings is a tedious, expensive and laborious process. The use of the marker eliminates this.

The marker is drawn length wise and cross wise over a field that has been thoroughly prepared. The implement marks

*This series of articles describe a number of simple implements used in India and Ceylon which are suitable for general adoption by the village agriculturist—*Editor, T.A.*



Block by Survey Dept. Ceylon.5 3 37

The Marker

out the field into exact squares. The seedlings are transplanted or the seeds are dibbled where the longitudinal and transverse lines cross each other.

Sometimes it is necessary to apply fertilizers a few days before transplanting or to make shallow drains with the plough between the rows of plants, as in tobacco cultivation. In either case the area has to be marked out first and the operations may obliterate the marking. Or again, a shower of rain just before the planting is begun may deface the markings already made. These difficulties can conveniently be overcome by fixing coconut leaflets or twigs at the junctions of the longitudinal and transverse lines immediately after marking out.

A man can easily mark out one acre a day. The implement can be constructed at a cost of about one rupee.

In cultivating crops like tobacco, the aim of the farmer should be to obtain a uniform crop in each block of 3 to 5 acres according to the capacity of his barn. To obtain this, the area should obviously be planted within a short space of one or two days. In such cases two to four markers should be used to expedite the work. In extensive cultivation of crops further economy can be effected by the use of large markers drawn by trained bullocks.

SOME STUDIES ON TOBACCO DISEASES IN CEYLON—I

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THE results recorded below are part of an investigation in which an attempt is being made to study closely the diseases of tobacco in Ceylon and the efficacy of control measures. The present paper embodies observations made on plants in the nursery and in the early stages of growth in the field and, in consequence, is restricted to a consideration of the two diseases which are most important in those stages of the plant's growth, namely, damping-off of seedlings (*Pythium* sp.) and frog-eye or eye-spot (*Cercospora nicotianae* E. & E.). The experiments were designed to provide, in the first instance, an estimate of the effect of surface-sterilization of seed and of regular spraying of plants in the nursery on the incidence of these diseases and to obtain information on the relative importance of the sources of frog-eye infection.

Experiments were carried out at the Experiment Station, Wariyapola, and the variety of tobacco used was Harrison's Special. The soil is sandy and deficient in organic matter. The rainfall during the last six years has varied between 60 inches and 100 inches and the average annual rainfall is about 75 inches. Tobacco is one of the regular rotation crops at Wariyapola and the experiments described below were carried out in the normal rotation area. Crops are grown during two seasons of the year, the *maha* season (September-October to March) and the *yala* season (March-April to June-July). The rotation is tobacco and a cereal crop during *maha* and a green manure crop grown and ploughed in during *yala*. Consequently, tobacco is planted on the same land during the *maha* season of alternate years. The tobacco is flue-cured,

EXPERIMENTATION

Preparation of Nurseries.—The nurseries were prepared in the manner usually adopted on experiment stations. A part of the rotation area not previously used for nurseries was selected, the choice being guided by the nearness of the water supply and the fact that the area was relatively level rather than by considerations of soil fertility. The nursery beds were 50 feet long by 4 feet wide and were about two feet apart. The soil of the beds was first deep-forked and a liberal dressing of cattle manure applied. The beds were raised about 18 inches above the level of the surrounding soil to permit free drainage. After the admixture of cattle manure, a layer of vegetable débris, consisting of maize cobs, sunnhemp stalks, etc. was placed on the beds and burned. This is the usual practice to reduce the incidence of damping-off disease and other nursery troubles; tobacco trash is never used for the purpose. The following manure mixture was added to every 20 sq. yards of nursery bed :—

$\frac{1}{2}$ lb. Sodium nitrate
$\frac{1}{2}$ lb. Potassium sulphate
1 lb. Superphosphate.

The nurseries were then worked in the usual way and the seed planted. Each nursery bed was covered with a roofing of plaited coconut leaves and, in addition, the beds were covered with cheese-cloth to protect the young plants from stem-borer attack (*Phthorimaea heliopa*).

The nursery treatment detailed above is the usual practice in departmental experiment stations in Ceylon and is more fully described by Livera (1935). In view of the fact that an experiment was contemplated, the operations were carefully supervised by the Farm Manager.

Seed.—The seed for the experiment was collected from selected Harrison's Special plants grown in another part of the same rotation area during the *maha* season, 1935-36. The flowers were bagged and the seed carefully cleaned before storage. That care was exercised in the collection and cleaning of the seed will be obvious from the results detailed below.

Part of the seed was surface-sterilized by the silver nitrate method used by Johnson and Murwin (1925) against wild-fire of tobacco. The seed was immersed in a 0·1 per cent. solution of silver nitrate in distilled water for 15 minutes, washed in several changes of tap water and then rapidly dried on sheets of blotting paper. It was found that the tap-water at Peradeniya is unsuitable for the preparation of the silver nitrate solution, owing to its high chloride content which causes a precipitation of silver chloride, which is of low fungicidal value.

One tablespoonful of seed was used for each seed-bed, the seed being mixed with sand to facilitate distribution. Each bed supplied more than a sufficient number of plants for one acre.

Spraying of Nurseries.—Spraying was begun 18 days after sowing, at which time the leaves were about 0·5 cm. across. One-half the beds were sprayed with a solution of Bouisol colloidal copper (1 oz. to 1 gallon water) using a pneumatic knapsack sprayer. A neutral spreader, Agral, was added to the spray solution at the rate of $\frac{1}{8}$ oz. per gallon.

The beds were sprayed at weekly intervals up to the time of transplanting. Spraying was carried out in the morning A little spray scorch was observed from time to time, especially on those plants at the ends of the beds which were subject to. more sunshine than the others. The scorch was never serious and very few plants were affected.

In order to overcome as far as possible the complication of insect injury in the nurseries, after the plants were five weeks old, all the beds were sprayed weekly with lead arsenate solution ($\frac{1}{4}$ oz. per gallon). The lead arsenate was added to the colloidal copper spray on the one hand, while, on the other, the remaining plants were sprayed with a lead arsenate solution to which a similar quantity of the spreader had been added.

At each spraying, it was found that $\frac{1}{2}$ to $\frac{5}{8}$ gallon of spray was used for each bed. The cost of the complete spray, excluding labour and appliances, was therefore about 15 cents for one bed and, as is stated above, each bed contained sufficient plants for one acre.

Lay-out of Nurseries. There were four treatments :—

1. Beds sown with sterilized seed and sprayed with colloidal copper.
2. Beds sown with untreated seed and sprayed with colloidal copper.
3. Beds sown with sterilized seed and unsprayed.
4. Beds sown with unsterilized seed and unsprayed.

The nursery consisted of sixteen beds which were divided into four blocks, each of four beds. The treatments were randomised in the blocks and the arrangement of the nurseries is given in table 1. For convenience, the treatments given above are denoted ST SP, UST SP, ST USP, UST USP respectively.

The general appearance of the nurseries is shown in plate I.

TABLE I

ARRANGEMENT OF NURSERY BEDS

Bed Nos.	*Block Nos.*	*Order of Treatment.*			
1–4	1	ST SP	ST USP	UST SP	UST USP
5–8	2	ST SP	UST SP	ST USP	UST USP
9–12	3	ST SP	UST USP	ST USP	UST SP
13–16	4	ST USP	UST USP	ST SP	UST SP

Transplanting.—The seedlings were planted out into the field seven weeks after the seed was sown. The plants from the first four beds were transplanted into a four-acre block which was divided into a 4×4 latin square of $\frac{1}{4}$-acre plots. The plants from the remaining beds were used for planting up the remainder of the area, 10 acres in extent. The seedlings from each bed were used for separate blocks of 1 acre each, so that, if necessary, areas of tobacco which had received the same nursery treatment could be used for later experiments.

RESULTS

For convenience, the results obtained are given below under the heading of damping-off disease and frog-eye.

Damping-off of Seedlings.—The use of a cheese-cloth cover over the beds to protect the seedlings from attack by stem-borer increased the humidity of the air immediately above

Plate I. General View of Nursery

the soil and so provided conditions favourable for the activity of damping-off organisms. That the amount of damping-off which occurred was relatively small, is an indication that the burning' of the nurseries before planting was fairly efficient.

Damping-off began to appear in the more crowded parts of some of the beds about four weeks after the seed was sown. The diseased plants were removed each day and counted, a note being made of the beds from which they were taken. An examination in the laboratory of diseased plants showed that they were attacked by *Pythium* sp. The numbers of diseased plants removed are given in table II below :—

TABLE II

NUMBERS OF DAMPED-OFF SEEDLINGS IN NURSERY BEDS

	Seed Treatment	*Sprayed*	*Unsprayed*	*Difference*
Block I.	Sterilized ..	0	322	+322
	Unsterilized ..	0	323	+323
Block II.	Sterilized ..	0	243	+243
	Unsterilized ..	19	297	+278
Block III.	Sterilized ..	0	313	+313
	Unsterilized ..	0	327	+327
Block IV.	Sterilized ..	0	237	+237
	Unsterilized ..	111	244	+133
	Mean ..	16·25	288·25	+272·0

$t = 11 \cdot 516$
$n = 7$
1 per cent. point = 3·499.

The above figures prove statistically that the difference between the sprayed and unsprayed beds is highly significant. Spraying with colloidal copper reduced markedly the amount of damping-off which occurred in the tobacco nurseries.

The surface-sterilization of the seed before sowing had, as might be expected, no effect on the incidence of damping-off in the nursery.

Frog-eye.—No frog-eye appeared at any time in any of the nursery beds. This was unfortunate in that the effect

of surface-sterilization of the seed on the incidence of frog-eye in the nurseries could not be determined. It was, however, a useful demonstration that, by the use of clean, carefully selected seed and by the careful preparation of the nursery beds, the appearance of frog-eye in the nursery can be avoided.

As has been stated above, the seedlings from the first block of four nursery beds were transplanted at the age of seven weeks into an area, four acres in extent, which was divided into a 4×4 latin square of $\frac{1}{4}$-acre plots. The transplanting was done with as much care and rapidity as possible. The four $\frac{1}{4}$-acre plots planted with seedlings from one nursery bed were planted out at the same time. Different baskets were used for transporting the plants of different treatments and the labourers washed their hands before transplanting each new set. The seedlings were planted 3 ft. apart between and within rows.

A storm, during which over two inches of rain fell, occurred on the day of transplanting and many plants were washed out but these were replaced as soon as possible. These and subsequent vacancies were supplied with plants from the corresponding nursery beds, as required.

In the centre of each $\frac{1}{4}$-acre plot a sub-plot of 100 plants (10 by 10) was roped off for critical examination. These observation plots were separated from each other by about 28 rows of plants in one direction and by about 30 rows in the other direction—a more than adequate supply of guard rows.

The first detailed record of the incidence of frog-eye was made four weeks after transplanting. A plant-to-plant examination was made in the sub-plots and records taken of the number of healthy leaves, the number of diseased leaves and the intensity of infection. A leaf was regarded as being infected whether it had one or twenty frog-eye spots. The number of spots on each leaf and the relative position of leaves so noted on the plants were recorded but, later, when the results were analysed, it was found that attempts to base calculations on the intensity of infection introduced such complications that it was decided to utilize the numbers of infected and healthy leaves only. The differences between the incidence

Tobacco Experiment Wariyapola
Frog-eye Infection

Block by Survey Dept Ceylon

Plate II

of frog-eye in the different treatments were so great that it was not necessary to consider the intensity of infection. Calculations based on the intensity of infection would merely have accentuated the differences recorded.

A diagrammatic representation of the incidence of frog-eye at the first examination is given in plate II. Each sub-plot contains 100 plants and each small black square represents a plant on which frog-eye was observed. The differences are striking.

For calculation, a random sample of 200 leaves was selected from each of the 100-plant sub-plots. The numbers of infected leaves in the random samples are shown in table III in which the relative position of the sub-plots is also shown, for clarity. The statistical analysis of these figures is given in table IV

TABLE III

NUMBERS OF INFECTED LEAVES IN RANDOM SAMPLES OF 200 LEAVES—FIRST EXAMINATION

UST	ST	ST	UST
USP	SP	USP	SP
87	3	77	7
ST	UST	UST	ST
USP	SP	USP	SP
61	4	47	3
ST	UST	UST	ST
SP	USP	SP	USP
3	42	5	60
UST	ST	ST	UST
SP	USP	SP	USP
4	43	3	96

TABLE IV

ANALYSIS OF VARIANCE — FIRST EXAMINATION

Due to —	Degrees of Freedom	Sum of Squares	Variance	$\frac{1}{2}\log_e$	Z	One per cent. point
Columns	3	803·19	267·73	2·7949	—	—
Rows	3	665·19	221·73	2·7007	—	—
Treatments	3	14588·19	4862·73	—	—	—
Sterilization	1	95·06	95·06	2·2773	—	—
Spraying	1	14460·06	14460·06	4·7896	2·0712	1·3103
Interaction	1	33·07	33·07	1·7493	—	—
Error	6	1378·37	229·73	2·7184	—	—
Total	15	17434·94	—	—	—	—

Standard Deviation = 15·16
Co-efficient of Variability = 44·5%

MEAN NOS. OF INFECTED LEAVES IN RANDOM SAMPLES OF 200 LEAVES

A. INDIVIDUAL TREATMENTS

ST SP	ST USP	UST SP	UST USP	General Mean	S.E. of Mean of 4 plots	Significant Difference
3	60·25	5	68	34·06	7·58	26·23

B. SPRAYING

Sprayed	Unsprayed	General Mean	S.E. of Mean of 8 plots	Significant difference
4	64·125	34·06	5·359	16·25

C. STERILIZATION

Sterilized	Unsterilized	General Mean	S.E. of Mean of 8 plots	Significant Difference
31·625	36·5	34·06	5·359	16·25

The effect of the surface-sterilization of the seed on the incidence of frog-eye in the field after transplanting is insignificant as is interaction between this treatment and the spraying. The variation due to these two factors is sub-normal. The effect of nursery spraying on the incidence of frog-eye after transplanting, on the other hand, is highly significant.

A second examination of the sub-plots was made twelve days after the first field examination. Records of the occurrence of frog-eye on random samples of 200 leaves were made n the same way. There was apparent a general increase in the amount of frog-eye in all the sub-plots. The results are tabulated below in the same way as for the first examination.

TABLE V

NUMBERS OF INFECTED LEAVES IN RANDOM SAMPLES OF 200 LEAVES—SECOND EXAMINATION

UST	..	ST	..	ST	..	UST
USP	..	SP	..	USP	..	SP
120	..	39	..	112	..	29
ST	..	UST	..	UST	..	ST
USP	..	SP	..	USP	..	SP
80	..	15	..	93	..	37
ST	..	UST	..	UST	..	ST
SP	..	USP	..	SP	..	USP
27	..	73	..	25	..	104
UST	..	ST	..	ST	..	UST
SP	..	USP	..	SP	..	USP
53	..	99	..	46	..	104

TABLE VI

ANALYSIS OF VARIANCE — SECOND EXAMINATION

Due to —	Degrees of Freedom	Sum of Squares	Variance	$\frac{1}{2}\log_e$	Z	One per cent. point
Columns	3	486	162	2·5438	—	—
Rows	3	1371·5	457·2	3·0625	—	—
Treatments	3	16606·5	5535·5	—	—	—
Spraying	1	16512·25	16512·25	4·8559	2·3911	1·3103
Sterilization	1	64	64	2·0795	—	—
Interaction	1	30·25	30·25	1·7047	—	—
Error	6	830	138·3	2·4648	—	—
Total	15	19294	—	—	—	—

Standard Deviation = 11·75
Co-efficient of Variability = 16·3%

MEAN NOS. OF INFECTED LEAVES IN RANDOM SAMPLES OF 200 LEAVES

A. INDIVIDUAL TREATMENTS

ST SP	ST USP	UST SP	UST USP	General Mean	S.E. of Mean of 4 plots	Significant Difference
37·25	98·75	30·5	97·5	66	5·88	20·35

B. SPRAYING

Treatments: Sprayed	Unsprayed	General Mean	S.E. of Mean of 8 plots	Significant Difference
33·9	98·1	66	4·16	12·61

C. SEED DISINFECTION

Sterilized	Unsterilized	General Mean	S.E. of Mean of 8 plots	Significant Difference
68	64	66	4·16	12·61

The effect of spraying in the nursery on the incidence of frog-eye is still highly significant. The variation associated with surface-sterilization of seed and with interaction is again sub-normal.

After the second examination was made the tobacco was primed and no further records of frog-eye in the field were made.

METEOROLOGICAL DATA

Daily rainfall records are given in table VII. Most of the rain recorded on the 18th October fell towards the conclusion of the transplanting of the four-acre block and destroyed a large number of the transplanted seedlings. With the exception of the two heavy showers recorded on 29th October and 6th November respectively light rain fell on most days up to the time of the second record of the incidence of frog-eye. Temperature fluctuations at Wariyapola are not sufficiently large to be of much interest.

TABLE VII

DAILY RAINFALL RECORDS FROM 15TH OCTOBER TO 30TH NOVEMBER, 1936

(Rainfall measured at 9 a.m. each day for the previous 24 hours)

October, 1936			*November*, 1936				
Date	*Rainfall*		*Date*	*Rainfall*		*Date*	*Rainfall*
15	—	..	1	·40	..	16	·04
16	—	..	2	·19	..	17	·08
17	·33	..	3	—	..	18	·66
18	3·61	..	4	·10	..	19	—
19	·29	..	5	·20	..	20	·03
20	·16	..	6	2·10	..	21	—
21	·84	..	7	·45	..	22	·17
22	·25	..	8	·25	..	23	—
23	·30	..	9	·47	..	24	·43
24	—	..	10	·85	..	25	—
25	·53	..	11	—	..	26	—
26	·12	..	12	—	..	27	—
27	·44	..	13	·02	..	28	—
28	·39	..	14	—	..	29	—
29	1·46	..	15	—	..	30	—
30	·37						
31	·03						

DISCUSSION

Hill (1936) demonstrated that frog-eye (*Cercospora nicotianae*) may be a seed-borne disease. He found viable spores of the fungus on tobacco seed after storage for twelve months. The experiment described above was planned to include observations on the effect of the surface-sterilization of seed by treatment with silver nitrate solution on the incidence of frog-eye in the nursery and the subsequent progress of plants from treated seed. The non-appearance of frog-eye in the nursery, even in beds containing plants which were grown from untreated seed and which were not sprayed, indicated the absence of any seed-borne infection in this instance. It also showed that any fungus which might have been present in the soil must have been destroyed during the burning of the beds, which was part of the preparation. Frog-eye infection of seedlings, however, does commonly occur in nurseries in Ceylon and it must be presumed that the precautions taken in the collection of seed and in the preparation of the nurseries were sufficient of themselves to eliminate nursery infection. These precautions were not exceptional, carefully cleaned seed from 'bagged' plants being used and the usual nursery practice, described by Livera (1935) in the preparation of beds being observed. The absence of frog-eye infection in the nursery unfortunately prevented any estimation of the effect of the surface-sterilization of the seed in this experiment.

Even if the incidence of frog-eye in the nursery can be prevented by careful observance of good nursery sanitation, the practice of spraying beds weekly with colloidal copper is justified by the almost protection it provides against damping-off.

In considering the field portion of the experiment, it should be noted that, although the lay-out of the experiment in the form of a 4×4 latin square assumes the existence of four treatments, there were, in fact, only two real treatments—sprayed and unsprayed. The nursery plants being free from infection at the time of transplanting, the surface-sterilization of the seed ceased to be a factor. The only difference among the plants was that the sprayed ones possessed a protective film of fungicide whereas the others did not. That this protective

film effects a marked reduction in the amount of frog-eye infection which takes place in the early stages of the plant's existence in the field is shown clearly in the statistical analyses recorded above. These results are really an under-estimate of the actual differences since they are based on estimates of the numbers of diseased leaves, whereas there was also a marked difference in the *intensity* of infection which, if taken into account, would accentuate the differences recorded; the intensity of infection was less on sprayed plants than on unsprayed plants.

Attention was given to a consideration of the sources of infection by frog-eye. It is generally held that one of the main sources of frog-eye infection is the incorporation in the soil of dead infected plant material from the previous year's crop. Hill (1936) has shown that diseased leaves may be a source of infection for at least two years. Both Hill (1936) and Sherbakoff (1932) have demonstrated that *Cercospora* can survive the process of flue-curing. Storing sheds adjacent to a tobacco field must accordingly be considered as potential sources of infection by means of air-borne spores. Alternate hosts of the fungus may also provide means of perennation but these are considered by Hill to be of little or no importance. Ceylon observations confirm this. Another possible source of infection is the seed. For the reasons stated above, however, no infection was introduced with the seed in this experiment. Infection of plants by the use of dirty seed, therefore, can be avoided but no opinion can be expressed in this article on the relative importance of infection from this source in ordinary cultivation.

A shed, which contained a considerable quantity of cured tobacco, was situated about 200 yards to the ENE. of the nursery and about 100 yards to the north of the area into which the seedlings were transplanted. The shed, which was built of plaited coconut leaves (cadjans), was closed on its southern and western sides, *i.e.*, the sides nearest the experimental areas. The cured tobacco was by no means free from frog-eye spots but no attempt was made to isolate *Cercospora* from it. It may be presumed, however, in view of the statements recorded above, that it was a potential source of viable spores of the fungus. The prevailing wind during the period under consideration was from the NE.

Some of the seedlings in the nursery beds were not removed from the nursery until after the first field examination was made. At that time the infection of the experimental plots was fairly general and the plots provided another potential source of air-borne spores. Nevertheless no frog-eye infection was observed in the nursery at any time. The main difference in the conditions under which plants were grown in the nursery and in the field was that the soil of the former was sterilized by burning whereas that of the latter was not.

Figure 2, as has been stated above, gives a picture of the distribution of infected plants in the sub-plots which were each situated in the centre of a $\frac{1}{4}$-acre plot. The distance between the end sub-plots of rows in a north and south direction was approximately 120 yards. If, therefore, the dissemination of spores from the storing shed was an important factor in frog-eye infection, there should have been apparent some difference in the intensity of infection in the sub-plots at the north and south ends of the field. No such difference was observed. The distribution of infected plants was, as can be seen from the figure, a uniform one and compatible with the assumption that the soil was the most serious source of infection of the experiment under review. In almost every infected plant, the lowest leaves were the first to be infected and it was common to find groups of frog-eye spots at the point where leaves actually touched the ground.

The suggestion that the soil was the most important source of infection is supported by the fact that no infection was observed in the nursery at the time of this examination. It is not suggested that the soil continues to be an important source once infection is established, but that it is the most important source of infection of the newly planted crop. Similarly, the evidence adduced tends to indicate that air-borne infection does not occur over any considerable distance.

The last crop of tobacco was grown on the same soil two years before this crop so that a period of at least 18 months must have elapsed since any tobacco material was incorporated in the soil. It is probable that this material, with the possible exception of some lignin, had all decomposed during that time so that, unless the fungus can live freely as a soil saprophyte,

it must have been present in the soil in the form of spores. It is suggested that the latter is probably the true explanation and that spores of *Cercospora*, which perennate in tobacco soils, provide the main source of infection.

CONCLUSIONS

From the experiment described above the following conclusions are drawn :—

1. That the selection of clean seed and the careful preparation of nursery beds may result in the absence of frog-eye infection in tobacco nurseries.
2. That spraying of seedlings weekly will control damping-off in tobacco nurseries.
3. That this spraying reduces considerably the initial infection of tobacco after transplanting into the field.
4. That the main source of frog-eye infection is the soil and that it is possible that the fungus perennates in the soil as spores.

ACKNOWLEDGMENTS

The thanks of the authors are due to the Divisional Agricultural Officer, North-Western Division, for his co-operation in the experiments and, especially, to Mr. A. B. Attygalle, Farm Manager, Wariyapola, for his helpful and willing assistance in the organisation of the field arrangements.

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THE CASE FOR REPLANTING OF OLD RUBBER ESTATES

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NEUCHÂTEL ESTATE, NEBODA

IT has become evident that old rubber of 30–35 years of age has passed its economic state and steps must be taken on such estates to replant it. Bark and leaf conditions are such that no amount of artificial manure can possibly recover the high yields that were harvested in the past. Tapping in its early stages was very different from tapping as carried out nowadays and it was not uncommon for 18 inches of bark to be removed in a year. The bark during the past 25 years has on old estates been removed and renewed 8-10 times so that it is not surprising that on many trees the renewed bark is so thin and hard that it cannot be tapped. Yields have dropped and are dropping and, with the present state of starvation on most estates and original bad opening, will continue to drop with the result that when restriction is removed those estates which have not large areas of young and vigorous rubber coming into bearing will be threatened with extermination.

It must further be remembered that the present rubber in Ceylon has in many cases not been manured at all and in others only during comparatively recent years, so that our efforts at cultivation now are analogous to a child that has been consistently starved until it has reached manhood and then efforts made to impart that growth and vigour that should have been done in youth. It is impossible with man and so it is with our present rubber.

We will now consider what one expects to gain by replanting and, for the sake of example, will take the case of an estate with 1610 acres of rubber in bearing, which decides to replant to the extent of 20 per cent. of its planted acreage as it is

allowed to do under the Rubber Restriction Ordinance during the years 1936, 1937 and 1938.

Year.		*Rubber in bearing*		*Replanted*
1936	..	1,610 acres	..	107 acres
1937	..	1,503 ,,	..	107 ,,
1938	..	1,396 ,,	..	108 ,,
1939	..	1,288 ,,	..	
				322 acres = 20%

We may assume that the 1,288 acres will from 1939 yield a crop of 708,400 lb. at 550 lb. per acre or 80 per cent. of the full crop that could have been harvested from the total acreage of 1,610 acres. It is likely that restriction will be continued for another term of 5 years after 1938 and it is unlikely that the percentage of release will be more than 80 per cent. during that time so that the crop is safeguarded up to an 80 per cent. release during restriction.

We will now assume that restriction ceases in 1943 and that the total 20 per cent. has been replanted as above. The first replanted 107 acres is then 7 years old and the assessment allowed by the Rubber Controller on 7-year-old rubber of approved clones is 6 lb. per tree. Given 120 trees to the acre this is 720 lb. per acre, rising in the 8th year to 8 lb. per tree and in the 9th year to 10 lb. per tree equivalent to 960 and 1,200 lb. per acre.

We may, therefore, in the 7th year of replanting expect the following crop:—

1943.	1,288 acres old rubber at 550 lb. ..	708,400 lb.
	107 acres budded rubber at 720 lb.	77,040 ,,
		785,440 ,,

and in the two subsequent years—

1944.	1,288 acres old rubber at 550 lb. per acre	708,400 lb.
	107 acres budded rubber at 960 lb. per acre	102,720 ,,
	107 acres budded rubber at 720 lb. per acre	77,040 ,,
		888,160 ,,

1945.	1,288 acres old rubber at 550 lb. per acre	708,400 lb.
	107 acres budded rubber at 1,200 lb. per acre	128,400 ,,
	107 acres budded rubber at 960 lb. per acre	102,720 ,,
	108 acres budded rubber at 720 lb. per acre	77,760 ,,
		1,017,280 ,,
	against a total crop if the estate had not been replanted of	885,500 lb.
	an increase of	131,780 ,,

and this with the budded rubber only in its 7th, 8th and 9th year.

It has again been assumed that the old rubber would be able to produce 550 lb. per acre in 1945 which with its very definite backward trend is doubtful, even though heavy artificial cultivation was carried out. I have taken for the purpose of these figures the actual assessments allowed by the Rubber Controller, but there is no doubt that the budded areas would continue to increase in yield until they too had reached their peak years. It is possible that when the budded rubber had reached the age of 13 to 15 years it would be giving 2,000 lb. per acre when the yields would stand as follows:—

1,288 acres old rubber at 550 lb. per acre	708,400 lb.
322 acres budded rubber at 2,000 lb. per acre	644,000 ,,
	1,352,400 ,,

It is quite certain that the old rubber would not continue to produce 550 lb. per acre even with cultivation so that it is obvious that if restriction came to an end in 1943 the only wise plan would be to replant the balance 1,288 acres of rubber, assuming that it was 30 years old or so. If this were done and the total 1,610 acres completed, at 12 years old a crop of 1,500 lb. per acre might be expected, or 2,415,000 lb.

I have not gone into the economic side of the cost of production on these crops as it is evident that as one can increase the yield so will the costs be reduced.

NOTES ON ORCHIDS CULTIVATED IN CEYLON
PHALAENOPSIS AMABILIS BLUME

EDWARD PERERA,
CURATOR, HENERATGODA BOTANIC GARDENS, GAMPAHA

FOR magnificence of flowers no genus of tropical orchids surpasses *Phalaenopsis;* plants of this genus are mostly natives of the very hot and moist parts of the Old World, their natural range extending from Assam and Burma, through the islands of the Indian Archipelago, to the Moluccas and Philippines. None of the species has pseudo-bulbs, but the leaves are generally thick and leathery. In several species the upper surface is prettily mottled with silver-grey, and the under side coloured a deep purple. The genus is distinguished by the grace with which the flowers are displayed. They usually face in one direction, and are elegantly supported on slender, frequently branching racemes. Another charm of *Phalaenopsis* is its remarkably free-flowering nature. A valuable property is the length of time the flowers remain in beauty.

The accompanying photographs of *Phalaenopsis Amabilis* Blume, a beautiful, free-flowering species, the flowers of which if kept dry, will remain fresh for several weeks. It has thick, elliptical, lance-shaped, brownish-green leaves, divided obliquely by a prominent midrib. The flowers are borne in two opposite rows, on long, pendent, often branching racemes. They are 3 inches in diameter, and are entirely white except the lip which, on the inner side, is spotted and streaked with rosy pink and yellow. In shape the sepals are broadly ovate, the petals being still broader and somewhat rhomboidal; the lip is three-lobed, the side lobes standing erect at each side of the column, while the central one divides at the apex into two slender, twisted filaments. It was found in Java and the Philippine Islands, and was first introduced into Ceylon in 1836. It flowers at various seasons, but most freely during the summer months.

Phalaenopsis Amabilis Blume

Culture.—Different species of *Phalaenopsis* are grown in different ways, and the one under reference represents a typical example of one grown in a bullock's skull with success.

Growing, as has already been stated, in some of the most tropical regions of the globe, on the trunks of trees and on the sides of rocks, where during the rainy season an immense quantity of rain falls, *Phalaenopsis* luxuriates only under conditions of great heat and moisture, and especially is this the case during the period of active growth. Pots and baskets, rafts and blocks of wood or tree fern trunks are much to be preferred.

In whatever position the plants are grown, a free and ample drainage is of the utmost importance. The material in which they are planted should consist of a thin layer of clean, fresh sphagnum or fibre placed upon a good layer of potsherds, porous brick, bone, and lumps of charcoal. They require, however, more moisture at the roots if grown on blocks or rafts, whilst if grown in pots more drainage will be required than when they are planted in baskets. Too much water must not be given to these plants at any time except when the plants are growing, and great care is necessary when they are inactive. The moss in which they are planted must never be allowed to get quite dry. Watering overhead should be especially avoided during dull weather.

The successful cultivation of *Phalaenopsis*, as well as of all other plants, depends upon efficient drainage. If grown on blocks or rafts they should be placed on good-sized ones so that there may be plenty of surface for the roots to cling to.

In fastening the plants on, first place a little sphagnum or fibre on the block, then fix the plant on with copper wire.

These plants are difficult to propagate, as they supply few opportunities for division. To this rule, however, *Phalaenopsis Luddemanniana* is an exception, as it produces young plants upon the flower scapes very freely. Sometimes the other species also will produce young plants on the old flower stems. It has been found that *Phalaenopsis Stuartiana* produces them upon its roots: when this happens they should be left on till well rooted and then placed on small blocks.

DEPARTMENTAL NOTES

THE MANURING OF PADDY IN CEYLON

A. W. R. JOACHIM, Ph.D.,
AGRICULTURAL CHEMIST

MANURIAL trials on paddy have been carried out by the Department in various parts of Ceylon. The results obtained have not always been the same at all places with the same types and quantities of fertilisers. This is due to the variation in soil, climatic and irrigation conditions, methods of cultivation and varieties of paddy grown. In general however, there is good evidence to show that paddy does respond to judicious manuring, whether with artificial fertilisers or organic manures like cattle manure, green manure and compost, and that economic returns can be secured thereby.

The fertilising constituents essential for increasing yields of crop on most paddy soils in Ceylon are nitrogen and phosphoric acid. In a few areas nitrogen alone, and in others phosphoric alone is beneficial; in the majority of the paddy areas, however, a combination of nitrogen and phosphoric acid gives best results. Where a field carries a luxuriant weed growth the nitrogen supply can be considered adequate; where weed growth is poor, both nitrogen and phosphoric acid may be lacking.

While artificial fertilisers alone are capable of increasing yields in most areas that have been under paddy for a number of years, the incorporation of some bulky organic manure along with the artificial fertiliser, in all but the soils well supplied with nitrogen and humus, is productive of even better yields. This is especially so on light soils poor in organic matter or on heavy clay soils. These organic manures, more particularly cattle manure, should not, however, be used in excess or there may be a danger of increasing the production of straw

at the expense of the grain, and/or of the lodging of the crop. One ton of cattle or green manure per acre would be a suitable application when artificials are used, and up to 5 tons per acre (on the average 2 to 3 tons) when applied alone. These organic manures are best applied at the second ploughing, but the soil should be kept well moist thereafter.

Of artificial fertilisers the following are to be recommended for paddy: sulphate of ammonia, superphosphate, basic slag, ammonium phosphate (niciphos or ammophos in two grades—narrow ratio and wide ratio) and steamed bone meal. The fertiliser which has been found most generally successful on soils of varying types is ammonium phosphate, whether as niciphos or ammophos. These fertilisers are therefore recommended for paddy at the rate of $\frac{1}{2}$ to 1 cwt. per acre depending on the nature of the soil and whether used in conjunction with organic manures. When applied alone $\frac{3}{4}$ cwt. of the fertiliser per acre is recommended for average soils. If applied with cattle or green manure $\frac{1}{2}$ cwt. per acre may suffice. Of the two grades of niciphos or ammophos, the narrow ratio grade (nitrogen and phosphoric acid each about 18 per cent.) should normally be used. It is cheaper than the wide ratio grade and appears to be as efficient as the latter on many soils. Where the soil is deficient in phosphoric acid but fairly well supplied with nitrogen, the wide ratio grade of ammophos (nitrogen 11 per cent., phosphoric acid 46 per cent.) or niciphos (nitrogen 14 per cent., phosphoric acid 43 per cent.), whichever is the cheaper, is recommended. In either case the fertiliser is best applied about a day before sowing or transplanting. It is essential that the soil should be well saturated with water before the application.

Where weed growth is very luxuriant and additional nitrogen does not appear to be necessary, an application of $\frac{3}{4}$ to 1 cwt. of either steamed bone meal, basic slag or ordinary superphosphate may be given. These are best applied at the final ploughing of the field.

On a very few soils, where the soil is rich in phosphoric acid, as in calcareous soils, sulphate of ammonia alone at the rate of $\frac{3}{4}$ to 1 cwt. is likely to be beneficial. The application may be given a day or so before sowing or transplanting.

Manuring should be resorted to only after other possible improved methods of cultivation have been adopted. Transplanting is one such method. Yield increases of over 25 per cent. can be obtained by transplanting as against broadcasting. While manuring does increase the yields of broadcast crops, the experimental evidence indicates that a larger yield increase is more likely to be obtained if the crop were transplanted. Where, however, transplanting is not feasible, as with early maturing varieties, manuring is recommended. It is advisable when no previous manuring has been done, that only a small area be treated in the first instance in order to determine whether the returns from manuring are economic or not.

In regard to the economics of paddy manuring, it may be stated that in general the cost of the fertiliser and its application should not exceed Rs. 7·50 per acre. If paddy is priced at Re. 1·50 per bushel, an increase of 5 bushels per acre would cover the expenditure on manuring. Generally speaking, yield increases of 20 per cent. and over equivalent to a minimum of from 6 to 8 bushels per acre, can be obtained with resultant profits. Where paddy is priced at Rs. 2·00 per bushel the returns from manuring should be correspondingly greater.

SELECTED ARTICLES

SOIL EROSION*

A VERY interesting address upon the development of tropical countries was delivered at the annual meeting of the Corporation by Mr. Stockdale, the Assistant Agricultural Adviser of the Colonial Office. His observations were of such importance in their bearing upon the future of our tropical and sub-tropical Empire that they should be closely studied by all who hope that that future will be full of steady progress and prosperity.

Among the important subjects which were brought up in the address, and with which we may perhaps deal at various times, was that of soil erosion, which plays a larger rôle than is always clearly understood. People who have not seen the rain fall in the tropics, especially in the monsoon countries that include so large a part of the Empire, are apt to picture it as something like the rain at "home." Our rain, however, except upon rare occasions, would be regarded there as a gentle drizzle.

If in England one clears a piece of land, the rain undoubtedly begins to wash it away, and to leach it, but at a rate that is hardly worth mentioning beside that which occurs in the tropics. There, a shower in which a whole month's English rain falls in a few hours is a common occurrence, and we have ourselves seen 10 inches of rain fall without a break in less than a day. Such rain rapidly washes away the surface soil, and leaches out the lower layers, so that in a few years after clearance the richest forest land may be reduced to the poorest possible condition.

The natural state of most of the land in the rainy countries of the tropics is to be covered with forest or coarse grass. In either case it is useless for general agriculture, but its soil is at the maximum degree of content of humus, plant food and water-retaining capacity (largely due to the humus) that occurs under natural conditions. These features—which, as everyone who works with agriculture in the tropics knows, soon diminish and largely disappear after clearance of the land—are the natural capital of the country. This capital should be conserved, not regarded—whether consciously or unconsciously—as something to be exploited until perhaps the land at the last must be abandoned (as one may see in many places). The real question is, how to get the best out of the land without destroying the natural capital more than can be helped.

* Editorial from The Empire Cotton Growing Review, Vol. VI, No. 4, October, 1929.

It is possible to live almost entirely upon the capital value of forest land, and this is the underlying explanation of the type of cultivation known in Ceylon as chena, in India as jhuming, in Malaya as ladang, and by other names in other countries. It is found almost all over the world where population is thin enough to allow to each person a large area of forest land. The trees on a portion of this are felled and burnt, and on the rich forest soil, further improved by the ash, a couple of crops of cereals or other products are grown and the land is then left to go back gradually to forest : it is again good enough to chena in ten to fifty years.

This is living upon capital purely and simply, for the land is abandoned as soon as it begins to become weedy, in order to avoid the labour of real cultivation. It is less trouble to chena a fresh piece of land. If population increase, however, as it has done for example in much of India and Ceylon, chena must perforce be given up and more real cultivation carried on. But this has, in such countries, to be done upon land where the natural capital, owing to reckless clearance, has been very much reduced. The result is poor and uncertain crops, varying considerably with the climate of the particular year (cf. article by Youngman in this volume, especially p. 43).

In districts where the people are more intelligent, or perhaps to be more exact, where pressure of population has compelled them to take more care, one may see attempts being made to rectify this state of things, by green manuring, rotation of crops, mixture of crops, and even by the use of actual manures, though in general cow-dung, which is almost the only available and cheap manure, is used as fuel, and so is largely lost. But there are distinct and recognizable attempts to put back something into the soil, or to equalize and minimize its rate of loss.

A state of things which is essentially very similar to this may be seen in most tropical regions opened up by Europeans in coffee, tea, etc. Largely through ignorance, they have used up the natural capital of soil, humus, etc., almost as rapidly as possible. Their planting of various crops has largely proceeded in " booms," in which there has been an insistent demand for land, and not sufficient foresight or knowledge on the part of the Government to curb this demand in the interests of future generations.

The result has been wholesale opening of land, usually in hilly country, where erosion proceeds more rapidly. The heavy rainfall has caused tremendous erosion and leaching, and has led to the silting up of rivers, causing floods and stoppage of navigation. A heavy price has frequently to be paid by a country that has been opened up for planting—not so much at the time, as later, when the results of the mistakes that were made in earlier times begin to appear.

Just as with the native industries above mentioned, so the planting industry has been forced to resort to the use of manures, of green manures, of terracing to prevent wash, of drainage, and so on. But the Government

can and should also assist, for example, by the provision of sufficient reserves of forest. In Ceylon, in early days, small strips of forest were left along the tops of the ridges, but they were so narrow that they were soon consumed for firewood, burnt, or otherwise rendered nugatory. However insistent be the demand for land, the Government should enforce the reservation of large areas in forest, in such a way as to prevent erosion (so far as possible), or the drying up of the streams in hot and dry weather, a common occurrence in such countries as Ceylon, where it adds greatly to the difficulties of water supply.

The provision of an officer for general service in the tropical and sub-tropical colonies, to deal with this whole question of prevention of erosion and of deterioration of soil, is quite worth the consideration of Government. But if appointed, he should spend a good deal of time in study both within and outside of the Empire, to see how the matter is dealt with, for example, in Java by terracing, etc., in China and Japan by the use of manure, etc., and in other countries in other ways. He should establish liaison with forest and irrigation officers, with engineers in charge of road-making, and others, and eventually with their assistance devise definite schemes for road, drainage, and forest reservations, and for all such matters which concern several departments (and which must therefore be carried out by definite orders from Governmental headquarters), in addition to working at the questions of manuring, green manuring, etc., which are the province of an agricultural department.

Nearly all countries which have been opened up for any kind of "planting" afford striking object lessons in what ought not to be done, and the newer colonies should profit by these lessons before it is too late, and should learn what ought to be done, and do it.

THE ROLE OF INSECTS AND FUNGI IN AGRICULTURE*

A PERUSAL of the original papers to be found in the twelve volumes of *The Empire Cotton Growing Review* which have appeared since 1924, and of the various publications of the Indian Central Cotton Committee since its inception, will show what a large proportion of the time and energy of the research workers has been devoted to the study of the insect and fungous pests which attack the cotton crops of the Empire.

If the excellent series of notes on current literature, which make this journal so useful to cotton workers overseas, be examined in detail, a similar conclusion will be reached. The cotton crop almost everywhere seems to come in for perhaps more than its fair share of pests. It would be interesting if figures could be published showing the total sums which have been spent in the British Empire since 1924 on the scientific investigation of cotton diseases, and also on the various remedial measures which have been adopted to control the various pests. The resulting figure would, I think, be astonishing.

When the Editor of this journal recently invited me to contribute an article on some subject of interest to cotton-growers, it occurred to me that I could not do better than sum up very briefly thirty years' experience of the diseases of cultivated plants, including cotton. During this period I have had first-hand experience in this branch of agricultural research in three continents—America, Asia and Europe—and have travelled widely.

THE DEVELOPMENT OF AGRICULTURAL RESEARCH

Let us consider for one moment how our existing research structure has arisen. As everybody knows, it is a comparatively modern development which started 100 years ago, when Boussingault laid the foundation of agricultural chemistry in 1834. The early pioneers were all chemists. Liebig's classical monograph on agricultural chemistry appeared in 1840. Lawes started work at Rothamsted in 1843, when the great era of chemical investigation began which continued for fifty years. During this period agricultural science was a branch of chemistry. Gradually the conviction grew that the problems of crop production could not be solved by chemistry alone. Hilgard and King's work led to the growth of soil physics. Pasteur's work on fermentation laid the foundation of the modern work on micro-organisms and disease. During the last forty years the plant-breeding and disease phases, in which we are now living, have been added to a structure which has always

*By Sir Albert Howard, C.I.E., formerly Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India and Rajputana in *The Empire Cotton Growing Review*, Vol. XIII, No. 3, July 1936

grown by accretion rather than by the development of a well-considered plan. Agricultural science—like Topsy—has grown. The present system of Agricultural Colleges, Experiment Stations and district organisations (within the Empire), for bringing the results of research to the farming community, is a very recent development of little more than thirty years.

Now it is a well-understood principle in business that any organization which expands by accretion stands in urgent need of periodical examination to ascertain whether the results obtained correspond with the cost, and whether any modifications are needed in the light of increased knowledge and experience. I began such an investigation of the plant disease section of agricultural science in 1905, and have steadily carried it on since. After thirty years' work, I feel sufficiently confident of my general conclusions to place them before the research workers in cotton in the various parts of the world.

Perhaps the best way of describing my investigation is to proceed more or less in chronological order, and to explain the gradual evolution of the somewhat revolutionary views that I now hold.

I began research on agriculture in 1899, at the age of twenty-six, as a mycologist, after a long scientific training—three years at the Royal College of Science, London, and three years (mostly devoted to biology and chemistry), at Cambridge, where I took both parts of the Natural Science Tripos as well as the Diploma in Agriculture. My first real contact with plant diseases was in connection with sugar-cane and cacao in the West Indies. Almost at once I discovered a fundamental weakness in the research organization : the mycologist had no land on which he could take his own advice before talking to the planters about remedies.

My next post was botanist at Wye College, where I learnt much from Sir Daniel Hall, whose experiments on hops I took over, and with whom I had many useful consultations. During my last year at Wye I had a small plot of land on which to grow a collection of fodder plants, but I had no hops on which I could try out certain ideas that were fermenting in my mind about the insect and fungous diseases of this interesting crop. It was only in 1905 at Pusa, in India, largely through the support of the Director, the late Mr. Bernard Coventry, that I had 75 acres of land on which I could grow crops in my own way, and study their reaction to insect and fungus pests and other things. My real education in agriculture then began—six years after taking my degree and obtaining all the paper qualifications and academic experience then needed by an investigator.

CROP MANAGEMENT AT PUSA

In 1905, at Pusa, at the beginning of the second and intensive phase of my education, I resolved to try out an idea (which first occurred to me in the West Indies), namely, to observe what happened when insect and fungous diseases were left alone and allowed to develop unchecked, and where indirect methods only, such as improved cultivation, were employed to prevent attack.

Accordingly, nothing was done in the way of prevention : no insecticides and fungicides were used : no diseased material was ever destroyed. As my understanding of Indian agriculture progressed, and as my practice improved, a marked diminution of disease occurred. At the end of five years, in 1910, the attacks of insects and fungi became negligible except in the case of a number of cultures whose root systems were afterwards found unsuitable for the soil conditions at Pusa. These were invariably attacked by disease, and I often had some difficulty in raising sufficient seed to maintain them from year to year. The advantage of these diseased plots in plant breeding was that they supplied abundant infecting material, such as rust spores, for testing the reaction of the rest of the cultures to fungous attack. My work at Pusa continued on these lines for an unbroken period of twenty years, during which hundreds of thousands of cultures were grown. The results, as far as insect and fungi were concerned, were consistent. Varieties which suited the local conditions, and which were properly cultivated, were always practically immune to disease. In the case of cotton, a crop which was grown for some years to determine to what extent cross-fertilization took place under Pusa conditions, it was evident that only the local North Bihar variety was able to withstand the large number of insect pests which found the great mass of Indian and American cottons such attractive provender. In the damp climate of Pusa the cotton crop, generally speaking, acted as a veritable magnet for every type of insect pest.

Between the years 1910 and 1916 the wheat investigations at Pusa were developed considerably. It was necessary to try out the improved types at a number of centres on the alluvium all over the Indo-Gangetic plain, and also on the black soils of Peninsular India. An excellent opportunity of observing the reaction of these cultures to rusts, and the geographical distribution of the various fungi, occurred. It was found that any variety which would stand up to rusts in the damp climate of Pusa did much better in this respect when grown in the drier wheat-growing areas of India proper.*

SOIL AERATION AND DISEASE INCIDENCE AT QUETTA

For a period of eight years—1910 to 1918—I was provided with a subsidiary experiment station on the loess soils of the Quetta valley, where the effect of different methods of cultivation and irrigation on the incidence of the insect diseases of fruit trees was studied. I observed no

*In 1910, in consequence of persistent importunity, I was allowed to have my own oxen at Pusa, and at once decided to make use of these animals for the study of disease. The greatest care was taken in the selection of the breed and of the type of animal ; the feeding, hygiene and management were as near perfection as I could make them.

I had my own oxen at Quetta and at Indore, and managed them on lines similar to those adopted at Pusa.

For twenty-one years—1910 to 1931—I was able to study the reaction of well-fed animals to the epidemic diseases such as rinderpest, foot and mouth disease, septicaemia and so forth, which frequently devastated the countryside. None of my animals were segregated ; none were inoculated ; they frequently came in contact with diseased stock. No case of infectious disease occurred. The reward of well-nourished protoplasm was a very high degree of disease resistance, which might even be described as immunity.

fungous diseases of fruit trees of any importance in the dry climate of Quetta valley during the eight summers I spent there. On the grape gardens run by the people on the well-drained slopes of the valley I never observed any diseases—insect or fungous—on the vines, although they were planted in the floors of deep trenches, and allowed to climb up the earth walls, mostly on the shady side. Flavour, disease resistance and a well-drained sub-soil all seemed to go together. The chief pest of fruit trees was green-fly soon after the young leaves appeared. This could be produced or avoided at will by careful attention to cultivation and irrigation. Anything which interfered with soil aeration brought on this trouble. Anything which promoted soil aeration prevented it. I frequently produced a strong attack of green-fly on peaches and almonds by over-irrigation during the winter and spring, and then stopped it dead by deep cultivation. Young shoots were covered with the pest below, but the upper portions of the same shoots were completely healthy. The green-fly never spread from the lower to the upper leaves on the same twigs. These observations were confirmed at Pusa for several years in the case of *Lathyrus sativus.* At this centre soil aeration was of supreme importance, and only surface-rooted types could obtain sufficient air for their roots. Deep-rooted varieties never did well. In the case of *Lathyrus sativus,* all the deep-rooted varieties were invariably attacked by green-fly. The shallow-rooted types alongside were always immune. The *Aphides* were never observed to move from the deep-rooted cultures to the shallow-rooted types alongside.

EFFECT OF SURFACE DRAINAGE AND HUMUS SUPPLY ON COTTON

At the end of 1924 I left Pusa to take up the direction of the Institute of Plant Industry at Indore in Central India, where the main crop was cotton. On the black soils there it was found that the two factors on which the yield and well-being of the American and Indian varieties of this crop depended were soil permeability and a supply of humus. Surface drainage, combined with dressings of fermented organic matter, produced cotton crops which appeared to be practically immune to all the local insects and fungi. One experiment I was unfortunately unable to try, namely, the importation of a supply of the various cotton boll-worms and boll-weevils from America, and the letting of these loose among my cultures. I offered to do this, however, when the question of the accidental importation of these pests into India was discussed. I am pretty certain that they would have found my cotton cultures very indifferent nourishment.

The contrast between the same varieties of Indian cotton when grown on the damp alluvial soils at Pusa and the dry, well-drained black cotton soils of Central India was most striking. Nothing could be done with cotton at Pusa on account of insect pests on the one hand and waterlogged soil on the other. For these reasons the large scale attempts to grow cotton in North Bihar in 1905 had to be abandoned. At Indore, during the seven years I was there, I cannot recall a single case of insect or fungous attack, although a large

number of varieties were grown every year, and the area under cotton always exceeded one hundred acres. The local cotton pests studiously avoided my cultures. I concluded they did not provide these pests with the nourishment they needed.

CONCLUSION REGARDING PATHOLOGICAL RESEARCH AND PRACTICE

So much for my general experience of the diseases of cultivated plants. My conclusions can be summed up as follows :—

1. Insects and fungi are not the real cause of plant diseases, and only attack unsuitable varieties or crops improperly grown. Their true rôle in agriculture is that of censors for pointing out the crops which are imperfectly nourished. Disease resistance seems to be the natural reward of healthy and well-nourished protoplasm. The first step is to make the soil live by seeing that the supply of humus is maintained.

2. The policy of protecting crops from pests by means of sprays, powders and so forth is thoroughly unscientific and radically unsound ; even when successful, this procedure merely preserves material hardly worth saving. The annihilation or avoidance of a pest involves the destruction of the real problem ; such methods constitute no scientific solution of the trouble but are mere evasions.

3. The protection of an area from imported pests is fortunately almost impossible to carry out in practice on account of the rapid improvement of communications and the increasing volume of traffic. If the present regulations were really effective, they would be harmful in that we should be deprived of a portion of the censors which Nature has provided for keeping our agriculture up to the mark.

It follows from these conclusions that the current views on diseases will have to be modified. This can only take place when the Empire possesses a number of entomologists and mycologists who have developed into real agriculturists and horticulturists, more or less on the lines I have indicated above. We shall then have a body of wide experience—scientific and practical —on these questions. Two things will have to be done before such workers are available :—

A. The system of training in pathology will have to be improved and widened. The future investigators of plant diseases, after a broad training in science, will have to learn agriculture, and to satisfy practical men that they possess real aptitude in growing crops.

B. The facilities for research in vegetable pathology will have to be vastly improved. Our future entomologists and mycologists will have to be provided each with a small experiment station on which they can grow crops and *on which practical growers can see for themselves workable solutions of their disease troubles.* Incidentally, the volume of the annual reports will be severely curtailed, as the details of life histories and nomenclatures will naturally become of very minor interest and importance.

Applying these considerations to the cotton crop, it is obvious that it is impossible to alter suddenly, by a stroke of the pen, as it were, the general policy now in operation with regard to the diseases of cotton. It must take a good many years before the insect and fungous pests of this crop can be regarded as censors for indicating something amiss either with the variety, with the general environment, or with methods of cultivation. During this intermediate period, I suggest that steps should be taken, wherever possible, to encourage mycologists and entomologists to grow cotton for themselves, and to become fully conversant at first hand with all the details of practical agriculture in the localities in which they are working. This is the first step on the new road. The next thing in the investigation of any particular disease will be for the workers themselves to try to ascertain the nature of the precise factor or factors, which have altered the cotton plant and made it attractive to the pest.

Working on these lines in India, I always found the appearance of insects and fungi on my cultures most useful and most stimulating. These organisms were my best teachers ; without them I should never have grasped the real factors underlying agriculture, and should have been a most unsuccessful plant breeder. I should never have devised the Indore method for the conversion of agricultural wastes into humus.

THE PEST AND THE PLANT*

We have been asked to make, from our comparatively limited experience, some comments on Sir Albert Howard's stimulating and original summary of his views on the rôle of insects and fungi in agriculture. His final conclusion that " Insects and fungi are not the real cause of plant diseases and only attack unsuitable varieties or crops improperly grown," may be true to a very large extent, but we find difficulty in accepting it unreservedly. In the case of the cotton crop we have come to recognize certain insects and diseases, notably a leaf miner and several leaf spots, as very reliable indicators of an unhealthy plant growing under unsuitable conditions, while jassid may cause quite serious damage even to the most resistant strains if they are improperly grown. Two groups of pests, however, the stainers and the American boll-worm, appear to provide exceptions to Sir Albert's rule.

* * * * * *

INSECT DAMAGE AND OTHER FACTORS

We feel that Sir Albert visualizes the whole population of insect pests and disease organisms lying in wait, as it were, to pounce upon the weakling plant. We hope, however, that we have produced sufficient argument to show that this is not invariably the case.

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* The above are extracts from an article by A. G. Bebbington and W. Allan in *The Empire Cotton Growing Review* Volume XIV, No. 1, January, 1937. The article is a reply to Sir Albert Howard's article reproduced above.

For want of space, extracts only have been published. The part of the article omitted provides detailed experimental evidence in support of the statements made.—Ed. T. A.

So far as we can see the attack of stainers on a cotton plot is determined by two broad principles :—

(*a*) The actual number of stainers that go to the crop is determined by the state and sequence of the wild hosts, and cotton should be regarded merely as a potential link in the sequence.

(*b*) The distribution of the stainer population over one crop is determined by the state and growth of the plants, but it is the most vigorous, healthy and best fruiting plants that suffer most. Further, so far as our scanty records go, we believe that this is also the case with American boll-worm.

While our experience has forced us to the view that insect damage may be a distinct and very important factor where cotton is concerned, we are now becoming painfully acquainted with other limiting factors of equal importance. On the looser types of Kalahari sand soils, which are theoretically ideal as regards freedom from stainer, the plant will not grow. In some of the upland areas early frost may be a limiting factor. In the lower valley regions of the Zambesi, where prolonged droughts are frequent, climatic conditions may be unsuitable. In a certain region of the transitional Kalahari sand a new pest, the giant cricket, has caused havoc. It would seem that the cricket damage can be avoided by early planting. If this is the case, have we found a true scientific solution by improving cultural methods, or are we practising the altogether unsatisfactory expedient of mere evasion ? In leaving the areas of heavy pest attack, are we practising this same expedient ?

Sir Albert's dictum, while it contains much truth, does not seem to be an altogether safe guide for ordinary practice because, sad though it may be, the world depends to a large extent on crops improperly grown. If he had been able to introduce the boll-worm and the weevil into India they might have found his cultures poor nourishment, though we have some doubts on this point, but there can be little doubt as to the effect on the commercial crop of India. In some measure this " improper " stage of agriculture must continue, for the amount of care given to a crop will be determined by the cash return and this, like all the other factors of production, is subject to the law of diminishing returns. Pliny possibly had some such thought in mind when he deprecated the excessively high standards of cultivation practised by the " gentlemen farmers " of the early Empire. " Are we of opinion, then, that ruin and starvation must be the necessary consequence of such a course as this ? Yes, by Hercules! and the very best plan of all is to let moderation guide our judgment in all things. To cultivate land well is absolutely necessary, but to cultivate it in the very highest style is mere extravagance."

CORRESPONDENCE

REJOINDER

To the Editor,
Tropical Agriculturist.

Sir,

Referring to the article on "Rotation Cultivation in the Wanni of Ceylon" :—The writer says that no rotation system is being practised in the Wanni ; this is the fact, but rotation has been talked of and written-up for the benefit of the villager for a generation ; the writer quotes the Jaffna peninsula where it is practised.

But there is the distance of the poles between Jaffna peninsula and the Wanni (jungle) mainland in village conditions of life. In Jaffna all the land is happily private land in possession of villagers to do what they like with, and they have the coral formation underneath and irrigate the land from wells. The jungles of the mainland are the exact opposite. In the jungles all the "chena" land, corresponding to the high land, "tidal," in Jaffna for rotation of crops, is Crown land which nobody can touch or use without a permit from Government and in which therefore there is none of the pride and magic of ownership felt by the Jaffna man and elsewhere in the world where ownership is in the cultivator. Thus the only place where rotation is practised is in Government Experiment Stations where implements, labour and overhead charges are all at the expense of the tax-payer for the last quarter of a century or more. In the article are enumerated the implements and everything needed for the cultivator to change over from what is styled the "time-honoured chena system" to the rotation system (known as "model chenas" among other aliases); but everybody who has lived like the villager in the Wanni for years knows that it is Nature which in the dry zone imposes on the population what is deprecated as the "time-honoured chena." Entirely apart from the land question the Wanni folk are totally without the means to change over to the expenses in their own cultivation on the scale of Government Experiment Stations ; and dry zone villagers cultivate to eat to keep alive, not to experiment and demonstrate like a Government garden.

It was only the extensive chena system which saved the dry zone from a much more devastating famine in the monsoon failures and distress between 1934-36.

I am, etc.,
H. R. Freeman

February 9, 1937.

TEA RESEARCH INSTITUTE OF CEYLON

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at St. Coombs, on Saturday, December 19th, 1936, at 2 p.m.

Present.—Mr. R. G. Coombe (Acting Chairman), Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs D. T. Richards, I. L. Cameron, R. P. Gaddum, J. D. Hoare and Dr. R. V. Norris (Director and Secretary) and by invitation Mr. J. W. Ferguson (Visiting Agent), Dr. C. H. Gadd (Mycologist) and Mr. P. H. Carpenter, Chief Scientific Officer, Tocklai Experimental Station, Assam.

Absent.—The Hon'ble the Financial Secretary, The Acting Director of Agriculture, The Chairman, Ceylon Estates' Proprietary Association, Mr. A. G. D. Bagot, and Col. T. G. W. Jayawardene, V.D.

The Notice calling the Meeting was read.

The Acting Chairman extended a very cordial welcome to Mr. P. H. Carpenter who, as he explained, had come down specially from India to discuss with the Director the programmes of work in the two research stations.

The Chairman also explained that as this meeting would be the last held before the Director proceeded on leave he had asked Dr. Gadd to be present.

MINUTES OF MEETING HELD ON 10TH OCTOBER, 1936

The Minutes of the Meeting of the Board held on 10th October, 1936, were confirmed.

MEMBERSHIP OF THE BOARD

(*a*). Reported that His Excellency the Governor had accepted with regret the resignation of Mr. D. H. Kotalawala from the Board.

The Chairman referred to the great interest Mr. Kotalawala had taken in the work of the Institute and proposed that a very cordial vote of thanks be recorded for the services he had rendered. This was carried with acclamation.

(*b*). Report thated Mr. J. D. Hoare had resumed his place on the Board on his return from leave, relieving Mr. B. M. Selwyn. A vote of thanks to Mr. Selwyn for his services was recorded.

SUB-COMMITTEES

(*a*). Reported that Mr. J. D. Hoare had rejoined the Finance Sub-Committee relieving Mr. B. M. Selwyn.

(*b*). The Board nominated Mr. W. W. A. Phillips of Mousakande Group, Gammaduwa, to act on the Experimental and Estate Sub-Committee during the absence on leave of Mr. James Forbes (Jnr.).

FINANCE

(i). *The Accounts to the* 31*st October*, 1936, were tabled and accepted.

(ii). *Estimates for* 1937.—The Chairman said that the estimate which had been circulated to the Board had been examined in detail by the Finance Committee and the comments of the latter Committee had been sent to Members. The Estate Estimates had also been scrutinised and approved by the Experimental and Estate Sub-Committee.

RESEARCH CAPITAL EXPENDITURE

Buildings.—With reference to the recommendation of the Finance Committee that a Rest House should be given preference over completion of quarters for Junior Staff, the Director asked that the matter might be reconsidered. Most of the Junior Staff were now married and the shortage of quarters raised many administrative difficulties. One Junior Staff Bungalow and one Clerk's bungalow were required.

Mr. Gaddum expressed the view that as the function of the Institute was research accommodation for the scientific staff should be first considered.

Major Oldfield asked whether if the quarters were built it might not also be possible to construct a small Rest House capable of enlargement later. The Director thought this possibility should be examined later when the financial position was more defined. The Acting Chairman said he had been in favour of priority for the Rest House but in the circumstances which had now arisen he did not wish to press this.

It was unanimously resolved to proceed with one Junior Staff Bungalow and one Clerk's Bungalow, and that the possibility of starting on the Rest House should be examined during 1937.

The estimate for Research Capital Expenditure amounting, after adjustment as above, to Rs. 15,000·00 was approved.

RESEARCH REVENUE ACCOUNT

The Estimate for Research Revenue Account amounting to Rs. 212,940·00 was approved.

ESTATE CAPITAL EXPENDITURE

The Board approved the recommendation of the Finance Committee that 16½ per cent. of the vote for General Charges in the Estate Working Account should be debitable to Capital Account.

The Board approved the estimate of Rs. 13,332·00 under Estate Capital Account.

ESTATE WORKING ACCOUNT

The revised estimate of Rs. 90,872·00 under Estate Working Account was approved. This is equivalent to 56·79 cents per pound gross. After allowing for items scheduled as special expenditure due to research, "Normal" cost of production will be 45·10 cents per pound.

EXPERIMENTAL & ESTATE SUB-COMMITTEE

The minutes of the meeting of the 21st November, 1936, were accepted without comment.

ST. COOMBS ESTATE

(*a*). *Factory Alterations.*—The Director reported the progress made in carrying out the improvements sanctioned by the Board in October.

(*b*). *Caddy.*—Reported that an agreement had been made to lease the caddy site to K. Saineris Silva of Holbrook, Agrapatana.

(*c*). *Visiting Agent.*—Arising from the Visiting Agent's report dated 14th October, 1936, the Chairman said Mr. Ferguson's recommendation had been either already carried out or provision made for this in the 1937 estimates.

Mr. Cameron asked if in view of the longer pruning cycle, the cultivation programme had been adjusted. The Director said this was so, the matter having been dealt with by the Experimental and Estate Sub-Committee.

The Chairman said that as this was probably the last meeting of the Board which Mr. Ferguson would attend before his retirement, he was sure the Board would wish to place on record a most cordial vote of thanks to Mr. Ferguson for the invaluable services he had rendered to the Institute, not only in his official capacity as Visiting Agent but also by his ungrudging assistance and advice on all occasions. Mr. Ferguson would carry with him on retirement their very good wishes and most grateful thanks.

Major Oldfield said that as the first Chairman of the Board, he would like to associate himself with all Mr. Coombe had said. He very much appreciated all Mr. Ferguson had done for the Institute.

Mr. Coombe's proposal was adopted with applause.

The Chairman said it would be necessary to consider the appointment of a new Visiting Agent. On Mr. Gaddum's suggestion it was decided to defer this question to the next meeting.

SENIOR SCIENTIFIC STAFF

(i). *Director.*—Reported that the Director's leave would now date from 16th February, 1937, instead of 21st February to fit in with steamer sailings. Approved.

(ii). *Mycologist.*—The Chairman asked the Board to consider the appointment of Dr. Gadd to the Selection Grade recently created. Major Oldfield strongly supported the proposal which was unanimously approved, the appointment to date from 1st January, 1937.

(iii). *Entomologist.*—The Board approved an increment of Rs. 50·00 per mensem due to Mr. King as from 9th December, 1936, in terms of his agreement.

The Board approved of Dr. Tubbs taking over full charge of the Agricultural Chemistry Section from 16th February, 1937, when the Director goes on leave, until Dr. Eden's return.

CONFERENCE

The programme for the forthcoming Conference was tabled and approved.

ANY OTHER BUSINESS

(*a*). Mr. J. D. Hoare was nominated to act as Trustee of the Junior Staff Provident Fund during the absence of Mr. James Forbes (Jnr.).

(*b*). The Board confirmed the nomination by the Junior Staff Association of Mr. G. D. Austin as their representative on the Medical Fund Committee, *vice* Dr. J. C. Shrikhande.

(*c*). *Publications.*—The Director said it had been suggested that the cost of printing the Institute's publications could be reduced by adopting a somewhat smaller type and that the rates charged for advertisements could be increased.

After examination of the sample pages submitted the Board decided to adhere to the present form and type but to raise the charges for advertisements to Rs. 30·00 per full page and Rs. 20·00 per half page.

(*d*). *Engledow Report.*—The Chairman invited Mr. Carpenter to address the meeting.

Mr. Carpenter, who explained that he was giving his personal views, first expressed his pleasure at being able to visit St. Coombs. This had enabled him to have a thorough discussion with the Director in regard to their respective programmes of work and he had also been able to see the work of individual sections.

He thought the most promising fields for closer co-operation would be in work on tea selection and fundamental problems such as the chemistry of tea. In regard to selection, Assam was well favoured in that their jats were more defined than those in Ceylon. The difficulty was still the basis of selection. They hoped at Tocklai to include quality as a factor and were trying to devise equipment for manufacture of leaf from individual bushes. At the same time means of propagation must be studied and he was glad to see that Ceylon was tackling the problem from this angle. In this way the work of the two stations would be complementary.

Mr. Carpenter also emphasised the importance of an exchange of visits between officers of the different Institutes. In this way a better understanding of general problems could be obtained.

Mr. Coombe thanked Mr. Carpenter for his remarks and again expressed the appreciation of the Board of his action in paying a special visit to St. Coombs.

The Chairman said the Director would be proceeding on leave before the next meeting of the Board and on behalf of the Board he wished Dr. Norris a very pleasant holiday.

The meeting then terminated with a vote of thanks to the Chair.

Roland V. Norris,
Secretary.

REVIEWS

The South American Potatoes and their Breeding Value.
The Experimental Production of Haploids and Polyploids. Publications of the Imperial Bureau of Plant Genetics (for crops other than herbage) Cambridge, England.

POTATOES have been grown in Europe for the last three and a half centuries, and available evidence goes to show that all the varieties grown at the present day are derived from the few isolated plants originally introduced from South America. The production of so many forms from so limited an amount of material was made possible by its extreme heterozygosity and its abundant fertility ; nevertheless, the limits of variation by inter-combination of characters were probably reached long ago, and further improvement is impossible without the introduction of complete new races.

An appreciation of this position led the Russian botanists to explore South America in search of breeding material ; they were rewarded by the discovery of a surprisingly varied collection of forms and species, growing under a range of conditions much wider than had been imagined. Potatoes were found in areas ranging from 40°S, through the Equator and even to the Tropic of Cancer, from sea level to 12,000 feet, from arid conditions to regions of abundant rainfall. The forms of *Solanum tuberosum* familiar in Europe were found in Chile, growing under conditions of climate comparable with those of France, but in other climatic regions were quite different forms, adapted to the conditions in which they lived. The material of most immediate interest to us was found in the Andean region, for it included "short-day plants", accustomed to conditions of almost equal day and night such as are found in the Tropics. Some of these forms will cross with *S. tuberosum*, and there is opened an entire new field of possibilities to the potato grower, in the production of new strains that shall carry the genus for resistance to disease and frost, high protein content or short dormancy, introduced from the South American parent.

Our difficulty in the past has been to make a long-day plant (*i.e.*, a temperate plant) grow under short-day conditions, and in the main we have failed. The Russian scientists, by their brilliant researches, and the Imperial Bureau by their enterprise in making available the results of these researches, have given us an opportunity of finding strains that will grow successfully under

tropical conditions, that will provide the dweller in the low-country with potatoes grown in his own garden.

This bulletin is a striking example of the services which the Imperial Bureaux are giving to the scientific workers. It owes its existence to a request from a correspondent for references on the experimental production of haploids. In supplying that demand an amount of information was revealed that warranted publication, and other scientific workers will benefit in consequence.

The artificial production haploids and polyploids has received increasing attention in recent years, and a surprising range of methods has been used with success. Chemicals, X-rays, high and low temperature, decapitation of the main stem, disease, even the centrifuging of germinating seeds have induced the formation of abnormal cells or groups of cells in somatic tissues, from which new plants may arise. Polyploid plants occurring in nature are probably the result of the union of abnormal sex cells, and such cells have also been produced by the methods mentioned above. More commonly, however, are they produced by the hybridization of plants of different chromosome numbers.

The production of polyploids may seem to be only of academic interest, but it has a definite economic importance, and with the rapid advances in knowledge that are being made, it seems only a matter of time before it will become a simple matter of technique.—J. C. Haigh

"Loris"—A Journal of Ceylon Wild Life—Vol. 1., No. 1. Published by the Times of Ceylon Company, Ltd., for the Ceylon Game and Fauna Protection Society.

THE birth of this little magazine is a most welcome addition to the very scanty popular literature on the wild life of Ceylon. Since the publication, in 1924, of Volume XII of *Spolia Zeylanica*, when it became a section of the *Ceylon Journal of Science*, there has been no specific local publication of a popular nature to cater solely for the needs of those interested in the natural history of Ceylon. The articles in subsequent issues of *Spolia Zeylanica* have tended on the whole to become more and more scientific in type and of less and less interest to the uninitiated nature lover. The present age is one of specialisation and rush, and with the advent of speedier and more comfortable means of travel the wild is continually giving way more and more to civilisation with its attendant upsetting of the balance of nature. It is this process which the proposal to create in certain areas strict natural reserves, national parks, intermediate zones and sanctuaries is attempting to stem, so that at least some of the wild shall remain for those of future generations who have eyes to see, ears to hear and the mind to read.

Popular articles on the natural history of Ceylon have been few and far between of recent years, and it has almost seemed as if the number of real nature lovers in Ceylon were slowly diminishing. It is to be hoped that this is not the case and that it only appeared so through there being no suitable outlet for their observations and notes of interest. The advent of "Loris" should undoubtedly fill a place that has been blank for some considerable time and there should be many interesting notes and reminiscences which have been kept for such an opportunity as they now have to appear in print. In view also of the large and varied insect fauna which Ceylon possesses it may be expected perhaps that some articles of interest and value on this subject will also appear from time to time.

The joint editors in their preamble to the first number of "Loris" indicate in delightful fashion the reasons which have prompted them to choose this apt title for their journal. Many of the articles are accompanied by excellent illustrations, and, with the keen interest that is being taken at the present time in wild life photography, there must be many treats in store to appear in future numbers. The article on this subject in the present issue should prove very helpful to those who are embarking on this boundless ocean of possibilities which modern photographic science has made available. 'Dawn Days' is a mass of information on the subject of which the author is an acknowledged authority; while the list of seventy birds seen in or from a Colombo

garden is an excellent example of what opportunities there are for good observation even in such urbanised surroundings. Most readers will find 'Leanama' a country to browse on with much pleasure ; it is a story of the Ceylon wilds told by the most appreciative and knowledgeable devotee we possess. The 'Holiday in Kenya Game Reserve' is one which will tempt many to start calculating when ways and means for a similar trip will be possible.

"Loris" has been extremely well turned out and printed and the only regret about it is that, as it is not priced, its circulation is perhaps restricted to members of the Ceylon Game and Fauna Protection Society. If this is be the case it is to be hoped that it is a matter which can be remedied at an early date.—W.C.L-S.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED FEBRUARY, 1937.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st, 1937	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	19	1	18	..	1	..
	Anthrax	..	..	..	..	..	..
	Rabies	3	1	..	..	..	3
Colombo Municipality	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	90	82	44	2	44	..
	Anthrax	7	..	..	7	..	..
	Rabies	5	3	..	5*	..	..
Cattle Quarantine Station	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	1	1	..	..	1	..
	Anthrax	3	1	..	3	..	..
Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	64	..	64	..	..	..
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
	Piroplasmosis	1	..	..	1	..	..
Southern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
Northern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	418	112	348	17	53	..
	Anthrax	..	..	..	..	..	..
Eastern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	61	61	61	..	..	..
	Anthrax	..	..	..	..	..	..
North-Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Rabies	2	..	..	..	..	2
North-Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	22	..	22	..	..	..
	Anthrax	..	..	..	..	..	..
Uva	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	88	8	77	3	8	..
	Anthrax	..	..	..	..	..	..
Sabaragamuwa	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Piroplasmosis	4	..	3	1	..	..

*All destroyed.

Department of Agriculture,
Peradeniya, 20th March, 1937

M. CRAWFORD,
Deputy Director of Agriculture (Animal Husbandry) & Government Veterinary Surgeon

METEOROLOGICAL REPORT—FEBRUARY, 1937

Station	Temperature: Mean Maximum	Temperature: Difference from Average	Temperature: Mean Minimum	Temperature: Difference from Average	Humidity: Day	Humidity: Night (from Minimum)	Amount of Cloud	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	86·6	−0·1	73·6	+1·8	73	93	4·7	7·09	8	+ 4·89
Puttalam ..	88·1	0	71·9	+2·0	74	95	3·5	2·82	7	+ 1·75
Mannar ..	87·3	+0·4	75·4	+1·9	73	88	3·1	0·67	3	− 1·06
Jaffna ..	86·2	+0·5	73·8	+1·8	70	90	4·8	3·13	5	+ 1·97
Trincomalee ..	83·2	+0·4	76·2	+0·5	76	84	4·6	6·06	8	+ 4·02
Batticaloa ..	83·4	+0·5	71·5	−2·1	75	93	5·6	9·76	15	+ 7·08
Hambantota ..	86·5	+0·6	73·6	+0·9	75	93	2·6	1·03	7	− 0·01
Galle ..	85·5	+0·1	74·4	+1·0	76	88	4·6	8·14	10	+ 5·15
Ratnapura ..	91·3	−0·5	72·4	+1·4	71	93	5·1	11·54	15	+ 7·10
Anuradhapura ..	87·1	+0·3	71·9	+2·5	70	95	5·6	0·90	6	− 0·59
Kurunegala ..	90·4	+0·8	70·8	+1·3	64	95	2·9	2·53	3	+ 0·84
Kandy ..	86·5	+0·6	68·2	+1·2	64	90	4·0	2·77	6	+ 0·97
Badulla ..	80·5	+1·6	65·2	+2·3	72	92	4·4	3·25	11	+ 0·76
Diyatalawa ..	75·1	+0·3	58·1	+2·0	74	91	5·0	7·22	11	+ 5·42
Hakgala ..	69·8	0	51·5	+1·1	78	91	6·4	4·13	12	+ 0·71
Nuwara Eliya ..	70·5	+0·6	45·8	+1·8	75	93	6·1	2·56	12	+ 0·85

The rainfall of February was above normal over almost the whole of the southern half of the Island, except for a few stations on the northern and north-western slopes of the hills, and stations along the coast between Matara and Hambantota, which were in deficit. In the northern half of Ceylon excess and deficit approximately balanced, the only districts showing appreciable excess being those between Batticaloa and Trincomalee, and the district just south of Mannar. Excesses over 10 inches were 11·14 inches at Haputale Hospital, 10·66 inches at Rasagalla, 10·49 inches at Horaborawewa and 10·44 inches at Kanankodu.

The highest monthly total of 23·60 inches were reported from Udugama Hospital. Other totals over 15 inches were 17·62 inches at Pallegama, 16·92 inches at Illukkumbura, 16·66 inches at Haputale Railway, 15·33 inches at Rasagalla, and 15·14 inches at Beausejour.

Eleven falls of at least 5 inches in a day were reported during the month, nearly all falling on the 13th. The highest fall was 9·25 inches, at Haputale Railway, on that date.

The widespread rains of the last days of the preceding month continued till the 2nd, on which day the rainfall was fairly heavy. Dry weather set in on the 3rd and lasted till the 12th. On the 13th there was fairly heavy and widespread rain, as a result of thunderstorm activities. Thunderstorms continued more or less till the end of the month, but the rain was chiefly light and spasmodic. At the end of the month, another dry spell set in.

Generally speaking, the night temperatures during the month were appreciably above normal practically everywhere, the chief exception being those on the 4th, 5th and the 6th, when the temperatures were well below normal. The day temperatures were only a little above average. Humidity was above normal, particularly by day, while cloudiness was also generally above normal. The barometric pressure was on the whole a trifle below normal. Wind strength was about normal, while its direction was, on the whole, north-easterly or easterly.

A hailstorm was reported on the 19th from Holmwood estate.

H. JAMESON,
Superintendent, Observatory.